

February 2017

Digital Resources for Worcester Cyclists

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WORCESTER POLYTECHNIC INSTITUTE

DIGITAL RESOURCE FOR BIKING IN WORCESTER

A WPI Interactive Qualifying Project

By Christopher Dallarosa, Quoc Ho Lam, James Kuszmaul, & Zach Simpson
3 March 2017

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This report represents the work of WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review.

ABSTRACT

Our project group worked with the Worcester, MA biking community to create a digital resource to increase the bike-ability of the city. Information was gathered from stakeholders across Worcester to develop a resource that incorporates preexisting biking resources as well as easily edited to add future resources. Ultimately, we created a website that includes tips and resources, bike security and maintenance, and information about local and national organizations. A biking specific mapping system was also created that indicated locations of, among other things, bike parking, bike lanes, and bike shops.

ACKNOWLEDGEMENTS

We would like to thank:

- Our advisors, Kristin Boudreau and Rick Vaz, for their help and feedback throughout the project
- Dan Daniska and Melissa Santley of CMRPC for taking the time to meet with us multiple times about the project
- Stephen Rolle, of the City Planning Department, for meeting with us to provide details about the existing bicycling infrastructure in Worcester
- WalkBike Worcester, for allowing us to take up most of one of their monthly meetings collecting suggestions and thoughts about what the website should contain
- Fritz's Bike Shop, Barney's Bicycle, and Bikes and Life for taking the time to answer some of our questions when we stopped by to collect feedback
- The WPI CS department for providing hosting for the website

EXECUTIVE SUMMARY

Alternative modes of transportation, including bicycling, have become more popular as their advantages have become clearer (Lobosco, 2014). Worcester, Massachusetts is the second largest city in New England, and while there are a great many people who might be able to bike, a variety of factors that make it harder for them to do so. Worcester has a young and modest biking infrastructure with some biking lanes, signage, and bike racks throughout the city. However, many people are not familiar with the existing infrastructure (Ackerman & Colfer, 2015) and are justifiably wary of biking without knowing where it is safe or easy to do so. We aim to make information about cycling in Worcester more accessible to a large audience, in this case by creating a website with a variety of helpful resources.

Methodology

The goal of the project is to create a digital resource that promotes biking in Worcester, MA, to bring together all the biking resources of the city to one location, and to provide a way for the biking community to communicate. To design a digital resource for Worcester bicyclists and potential cyclists, we took the following steps:

- Conduct background research into preexisting biking resources in Worcester and other parts cities throughout the country
- Determine the needs and concerns of community stakeholders
- Determine what type of digital resource would best facilitate the needs based on the community feedback
- Create a website and bike specific mapping system that provides useful information to the biking community
- Collect feedback on the website and make improvements based on that feedback

We considered groups such as Central Massachusetts Regional Planning Commission (CMRPC), Walk Bike Worcester, Worcester Earn-a-Bike, various bike shops in the city, and Planning & Regulatory Services at City of Worcester as our key stakeholders. Each group was contacted for opinions and concerns about the current bikeability of Worcester. We also consulted existing resources for other cities and considered their features when building our own website. This included using some of the open source code from an existing website for visualizing route elevations.

We explored several options for how to implement the website in the map and settled on a particular platform for the website and on using the Google Maps API for the map. We then implemented both the website and map, taking into account what other resources had done in the past as well as what we had learned from the interviews with the local stakeholders.

After we implemented the website, we returned to the various groups we had interviewed earlier and got feedback on what we had implemented. We then made what improvements we could to the website based on this feedback, and incorporated the rest of the feedback into our recommendations for future improvements to the website.

Results

Based on our research and interviews, we designed and implemented a website to address the suggestions to the best of our ability. We ended up creating a website that includes two major features:

1. Articles containing various useful information for cyclists (e.g., information on how to maintain a bicycle).
2. A map which displays useful information for cyclists on top of Google Maps Directions

The website itself is mobile friendly and contains articles on anything from bike pre-ride checks to what to do if you are in a bike accident. The information provided was based on the feedback we got from various stakeholders, with the articles sourced from various existing resources.

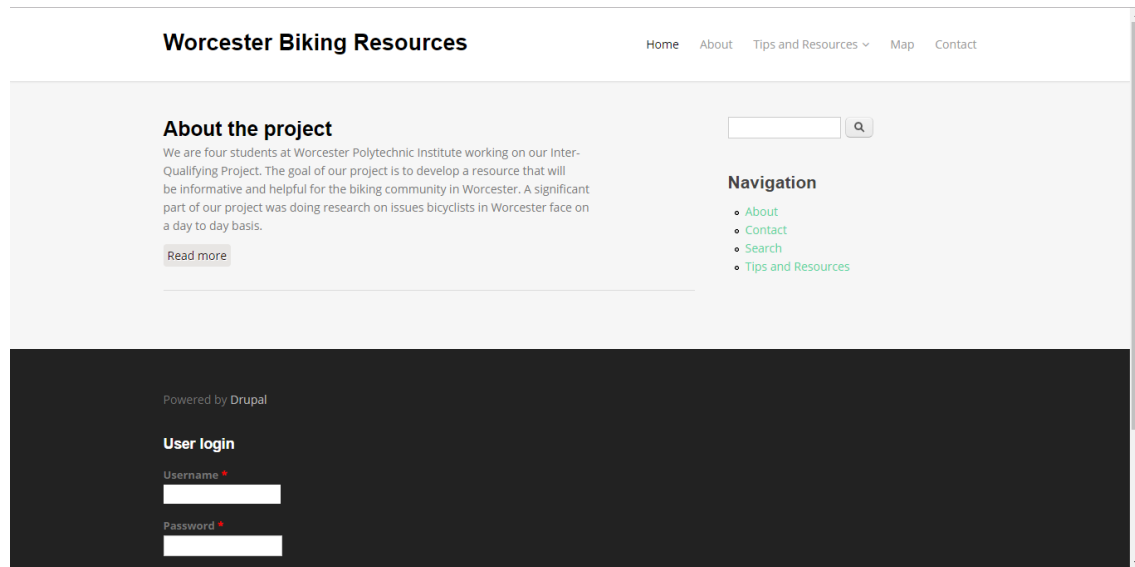


Figure 1: The Website's Home Page

For the map, while we did end up using Google Maps to allow users to get directions between locations (meaning that the routes we provide are no different from what is shown on Google), we do provide additional information on the map so that users can more easily see whether the route they are going on might include bad roads or hills. There are also displays for the locations of bike parking (and the potential for any new location type to be added), to help people know where they can park their bike when they are going somewhere.

Because we did not have the resources to map every single bike parking location (or bad road or intersection), and because things will change in the future, we also built the map to allow anyone who visits the map to contribute knowledge by suggesting markers. For instance, if they know of a bike rack near where they work, they could suggest it and then an administrator can choose whether to approve the marker for publication on the map.

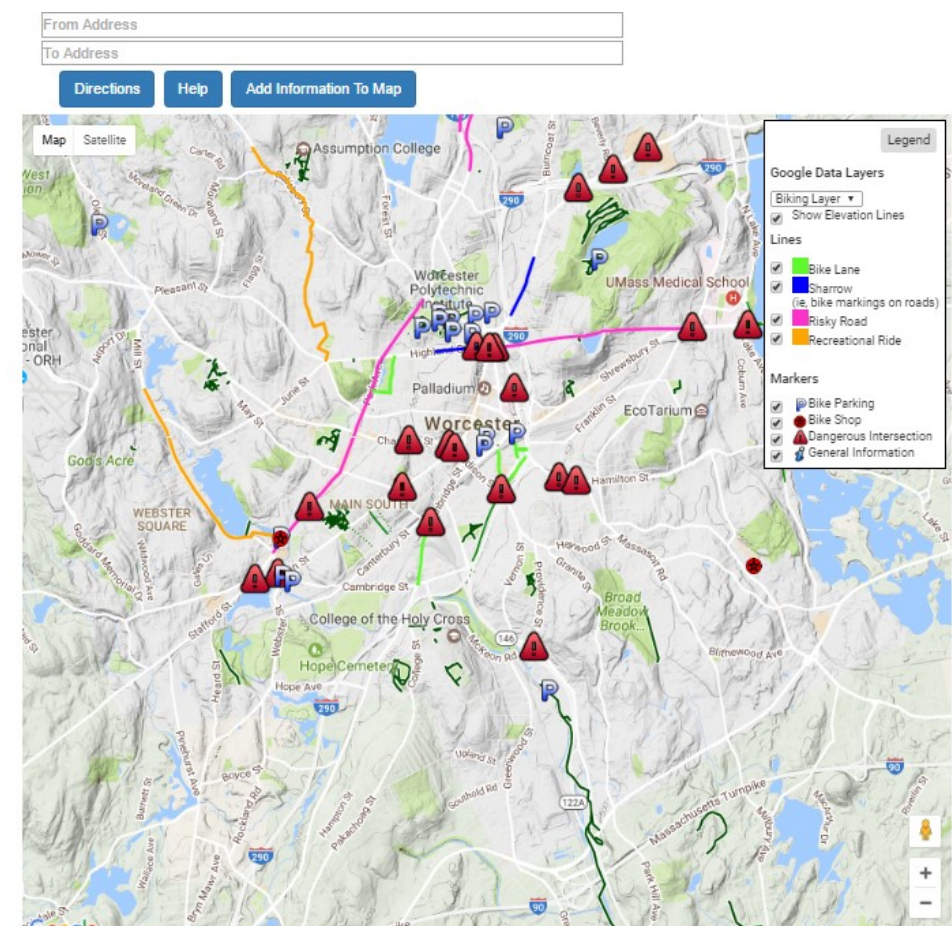


Figure 2: Bike Map Resource

Conclusions and Recommendations

This resource looks to give bicyclists in the City of Worcester a central resource of information that is relevant to specifically Worcester and cycling in general. The aim of the project was to be able to give bicyclists in the City of Worcester a central hub of information relevant to bicycling.

Ideas from this website were gathered from similar websites that were looking to accomplish a similar task of showing roads and places that are safe for bicyclists. Some features of our map were inspired by the ideas of other websites and maps.

Features of the map include:

- Map of bike lanes and sharrows users have added
- Bike parking
- A description of the type of parking
- Risky roads: Roads that may be dangerous for bicyclists to ride on
- Dangerous intersections: These are intersections that have high crash statistics and therefore should be avoided if possible.
- Ability for users to add risky roads, dangerous intersections, bike parking to the map

- Ability for cyclists from the bicycling community to add roads to the map that are not roads with bike lanes or sharrows, but may be safe alternative for cyclists to ride on
- Feature allowing users to add places where they think that bike lanes should be added

Features on the website include:

- Helpful articles on topics such as:
 - Public Transit
 - Local Bike Shops
 - Group Road Rides in Worcester
 - Massachusetts' Bike Law
 - Recreational routes
- A contact form to make it easy users to get in touch with whomever is maintaining the website

Based on our experiences in building the website and on the feedback that we received from various groups around Worcester on the website, we formed a set of recommendations for future work:

1. Rewrite Map Using Open Source Alternatives for Greater Customization.

We recommend that an organization rewrite the map using open source alternatives as a base platform, instead of using Google Maps as a platform. Using an open source alternative would allow greater customization of mapping features, potentially improving user experience. The main reason that we used Google Maps instead was to reduce the workload while still providing a useful resource.

2. Fix Outstanding Map Bugs

We recommend that an organization fix any outstanding map bugs that may be present in the map. Due to the time constraints given to create the map, we were not able to find and fix all the bugs that may be present. We include a list of these bugs in Appendix A.

3. Create an iPhone/Android Compatible App

We recommend creating an application specifically for iPhone and Android operating systems. Creating an iPhone/Android compatible application would ideally give users a smoother experience while using the application on their phone, and allow greater customization.

4. Improve the Map's User Interface

The most common piece of feedback on the map was that many of its features were non-obvious and that, while the map might make sense once you get used to it, most people did not immediately understand what all the features and buttons meant. A dedicated effort by someone who understood user interface design would go a long way towards improving the map.

The completed website can be found at <http://bikemap.wpi.edu>

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-Challenges Bicyclists Face	Tommy (Quoc), James
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--Safety	Tommy
--Limited Number of Bike Lanes	Tommy, Chris
--Other Challenges	Tommy
-Available Resources in Worcester	Tommy, Chris
-Elements Of Digital Mapping Resources	All
--Mapping	All
---Cycling Routes	Chris
---Indicating Elevation	James
---Location of Bike Utilities	Tommy, Chris
---Locations of Safest Routes	Chris, Zach
---Providing Multiple Directions	Chris
--Promoting Biking	Chris, Tommy
Methodology	All
-Determining What Information and Features Users Need	James
-Retrieving Data	James
--Retrieving Information from Worcester Cyclists	James

-Implementing the App	James
--App Platform Options	James
-Getting Feedback on the Website	James
-Future Maintenance of the Website	James
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-Community Biking Needs	Zach
-Digital Resource	Zach, James
-Issues Encountered	James
Conclusions and Recommendations	Chris, James
-Summary of Project Deliverables	Chris, James
-Recommendations for Future Development	Chris, James
--Information on Bike Lanes in Worcester	Chris
--Future Research and Development	Chris, James
Appendix A	James, Tommy
-User Manual	Tommy
-Technical Documentation	James

TABLE OF CONTENTS

ABSTRACT.....	i
ACKNOWLEDGEMENTS.....	ii
EXECUTIVE SUMMARY	iii
Methodology.....	iii
Results.....	iii
Conclusions and Recommendations	v
AUTHORSHIP	vii
TABLE OF CONTENTS.....	ix
LIST OF FIGURES.....	xi
LIST OF TABLES.....	xii
CHAPTER 1: INTRODUCTION	1
CHAPTER 2: BACKGROUND	3
Worcester’s Biking Infrastructure	3
Challenges Bicyclists Face	5
Worcester’s Topography.....	5
Road Safety	6
Limited Number of Bike Lanes	7
Other Challenges.....	8
Available Resources for Bicyclists in Worcester	8
League of American Bicyclists.....	8
National Bike Registry	8
Worcester Earn-a-Bike	8
Elements of Digital Mapping Resources	9
Detailed Mapping.....	9
Promoting Biking.....	13
CHAPTER 3: METHODOLOGY	15
Determining What Information and Features Users Need.....	15
Retrieving Data	17
Retrieving Information from Worcester Cyclists	19
Implementing the App	19
App Platform Options	20

Getting Feedback on the Website	21
Future Maintenance of the Website.....	23
CHAPTER 4: DESIGN FEATURES.....	24
Community Biking Needs.....	24
Digital Resource	24
Challenges Encountered	28
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS.....	29
Summary of Project Deliverables.....	29
Recommendations for Future Development of the Digital Resource	30
Information on Bike Lanes in Worcester	30
Future Research and Development	31
APPENDIX A: DOCUMENTATION.....	34
APPENDIX B: INTERVIEWS.....	34
Interview with Central Massachusetts Regional Planning Commission (CMRPC).....	34
Interview with WalkBikeWorcester,	36
Interview with Fritz’s Bicycle Shop,	36
Interview with Barney’s Bicycle,	37
Interview with Bikes and Life,	37
APPENDIX C: Website Feedback	38
Amy West, Sent feedback via email (2/5/17)	38
David Dayan, Sent feedback via email (2/7/17).....	38
Carlos Barcelos, WPI Green Team Vice President (1/25/17)	38
Meeting with Dan Daniska and Melissa Santley from CMRPC (1/30/17)	40
Barney's Bicycle Shop(2/14/17)	41
BIBLIOGRAPHY AND PHOTOGRAPH SOURCES.....	41

LIST OF FIGURES

Figure 1: The Website's Home Page	iv
Figure 2: Bike Map Resource	v
Figure 3: Sample biking directions between WPI and Union Station (Google Maps)	4
Figure 4: Topographical map of Worcester, Massachusetts (Topographic Map of Worcester, 2016)	5
Figure 5: Topographic Map of Portland, OR	6
Figure 6: Bar chart from the U.S. Bicycling Participation Benchmarking Study Report which illustrates the percentage of people, by region, who are afraid of being hit by a car while bicycling (Breakaway Research Group, 2015).	7
Figure 7: Comparison of Worcester (left) bike lanes on Google Maps compared to that of Boston (right)	7
Figure 8: Cycle.Travel Map of road and bike lanes in the city of Worcester in England (Worcester Cycling Guide with maps and routes, n.d.).	10
Figure 9: Sample directions between WPI and Union station using Flatthest Route	11
Figure 10: A Section of map of Tacoma, WA Bike Paths (Pierce County, n.d.)	12
Figure 11: Sample route created in Ride the City Boston (Ride The City--Boston, n.d.)	13
Figure 12 Map of Best Routes to Get into Boston from Outlying Communities (City of Boston, n.d.)	14
Figure 13 My City Bikes: Phoenix, (Phoenix Blkes App, n.d.)	14
Figure 14: Home Page	25
Figure 15: Mobile View of Homepage	26
Figure 16: The user's first view of the map upon opening	27
Figure 17: Viewing Directions on the Map	28

LIST OF TABLES

Table 1: Intersections with the Most Accidents in Worcester, MA	18
Table 2: App Platform Options.....	20

CHAPTER 1: INTRODUCTION

Alternative modes of transportation have become more popular as their advantages have become clearer (Lobosco, 2014). Although 85% of commuters still use cars (US Census, 2014), the advantages for biking are numerous. For instance, bicycles do not produce any harmful emissions and are better for the environment and more sustainable (Peach, 2011). Being cheaper than cars, bicycles are more accessible to large parts of the population (Roth, 2011). Bicycling also encourages people to exercise and stay healthier than they might otherwise. In cities with particularly bad congestion, biking may be as fast or faster than a car during rush hour, while also reducing the number of cars on the road.

Worcester, Massachusetts is the second largest city in New England, and while there are a great many people who might be able to bike, a variety of factors may dissuade them from biking. Worcester has a young and modest biking infrastructure with some biking lanes, signage, and bike racks throughout the city. Unfortunately, many people are not familiar with the existing infrastructure (Ackerman & Colfer, 2015) and are justifiably wary of biking without knowing where it is safe or easy to do so.

One challenge is a perception that biking in Worcester is difficult. For instance, Worcester is a rather hilly city. People who are either unfamiliar with biking techniques to bike up and down hills or lack the physical ability to do so may be dissuaded from going out if they must bike up and down steep hills. However, it is generally possible to avoid very steep hills, so long as one follows the right route. This also applies to avoiding heavy traffic. Many streets and intersections in Worcester are particularly unsafe or just unsettling, but are avoidable with the right planning.

A study at the University of Edinburgh in 2015 listed the lack of awareness of existing cycle paths and infrastructure as a recurring complaint among students. The University has a variety of resources for its students such as bike repair facilities. However, in many of the interviews, the University found that many students were either unaware or had limited knowledge of existing resources on campus for bicyclists. Similarly, a study at WPI found that many of the interviewees thought there was a lack of bicycle resources in Worcester (Ackerman & Colfer, 2015).

Regardless of the physical resources, there exist a number of digital resources from places around the world meant to make cycling easier for individuals. With the thought of minimizing elevation changes throughout a trip, Zivi Weinstock developed a program called Flattest Route (Weinstock, 2013), a web app that utilizes Google Maps API to find the flattest route between two given points. Another notable app is RackIt, developed for the University of Kansas by Jay Decker (Farber, 2013). This app allows students to visualize and find bike racks around campus. Despite the existence of these apps in other cities, there has yet to be one developed that addresses the problems of biking in Worcester.

As the city of Worcester's biking community increases through scheduled rides from local bike shops and bike signage and lanes, biking infrastructure improvements have appeared. Currently, a plan is being devised to improve a 1,500-foot section from Main Street to Beaver Street, which will improve foot and bicycle traffic. Main St is one of the busiest streets in Worcester, and the renovation will include five-foot wide bike lanes and old traffic signals replaced with overhead signals, increasing traffic flow in the area. The road will also be changed from a four to three lane road, making room for a left-turn only lane to improve vehicle traffic (Murtishi, 2016). The project is estimated to start in the summer of 2017 and cost \$2.3 million. If approved, the renovations could extend further along Main Street,

totaling \$9.8 million in improvements in a two-year span, from state and federal funding. Worcester also has other plans for improved biking around the city, such as expanding bike parking, implementing a city-wide bike share program, extending the Blackstone Valley Bike trail, adding Park St/Chandler St bike lanes and bike lanes to connect city colleges, and extending bike lanes from Webster Center to Union Station. Behind these plans is the Central Massachusetts Regional Planning Commission (CMRPC), an organization responsible for promotion of alternate transportation of people and goods, comprehensive and technical planning services, and provide grant assistance to the Worcester region.

With improvements to the biking resources in Worcester, there is a need for a resource that collects all the information into one location. An easily accessible digital source that is consistently updated with information on biking routes, biking organization events, and tips for biking in Worcester will help the biking community communicate to each other. This resource should be mobile friendly and targeted at helping people in Worcester who are interested in biking or who already bike but are uncomfortable biking in parts of the city that they aren't used to. It would provide a central resource for information such as the safest, fastest, and flattest bike routes to take while bicycling in Worcester. Also included would be information on the location of bike lanes and parking, accident prone intersections, terrain for avoiding hills, and assorted other information. Our goal is to develop a resource that can be maintained after its initial creation and be updated as new bicycling resources are added around Worcester. With these features, we offer the Worcester community an informative and helpful resource for biking.

CHAPTER 2: BACKGROUND

In this chapter, we discuss the current state of Worcester's biking infrastructure and plans to improve it. We then look at the challenges that many bicyclists face, some of which are specific to bicyclists in Worcester. This chapter will then discuss the solutions other places implemented to address these challenges.

Worcester's Biking Infrastructure

Efforts to modernize Worcester's biking infrastructure first started in the 1990s, when the ISTEA (Intermodal Surface Transportation Efficiency Act of 1991) created funding and collaborative planning for highway and transit. This then resulted in the NBWS (National Biking and Walking Study), which resulted in a 1994 report and 1999 and 2004 status updates (Administration, 2004). The NBWS, ISTEA, and the 1999 TEA-21 (Transportation Equity Act for the 21st Century) helped set the agenda to increase biking and walking in America.

Within Worcester, these funds resulted in some ambitious plans (in 1998) to implement bikeways connecting the entire city, but only a portion of the bikeways were constructed, and since then some of the bike lane markings have faded and streets that were modified to be bike friendly may no longer be (Capizzio, Hunter, Martin, & Miller, 2012). More recently, bicycle accommodations such as bike lanes, signage, and bike racks, have been a consideration when revamping city streets (Ackerman & Colfer, 2015).

At WPI, several student projects (IQPs) have recently focused on alternative transportation and bicycling. The earliest of these IQPs, in 2012, proposed several possible plans for where to put bikeways/lanes/markings, depending on the city's priorities (mostly comparing budget and comprehensiveness) (Capizzio, Hunter, Martin, & Miller, 2012). A couple years later, another IQP investigated general alternative transportation options for the WPI community and produced a recommendation for, among other things, a bike share program at WPI (Hannoush, Cyr, Josephs, & Mikelonis, 2014). This recommendation was then fleshed out in the following year, with a full-fledged plan for such a bike share program, which has since been implemented (Ackerman & Colfer, 2015).

Now that more WPI students have a way to get bicycles and with the city adding more biking infrastructure during road renovations, the need for a more centralized bicycling information has become more acute; there is no clear centralized resource for information on bike trails, bike lanes, accident statistics, bike shop locations, etc. To some extent, this information can be found through Google Maps right now. Google Maps has an option to get biking directions, contains incomplete information on the locations of bike trails and lanes (which is incorporated into its biking directions), will provide information on the hills along a route, and, as with any type of business, the user can search for "bike shops" and receive a result.

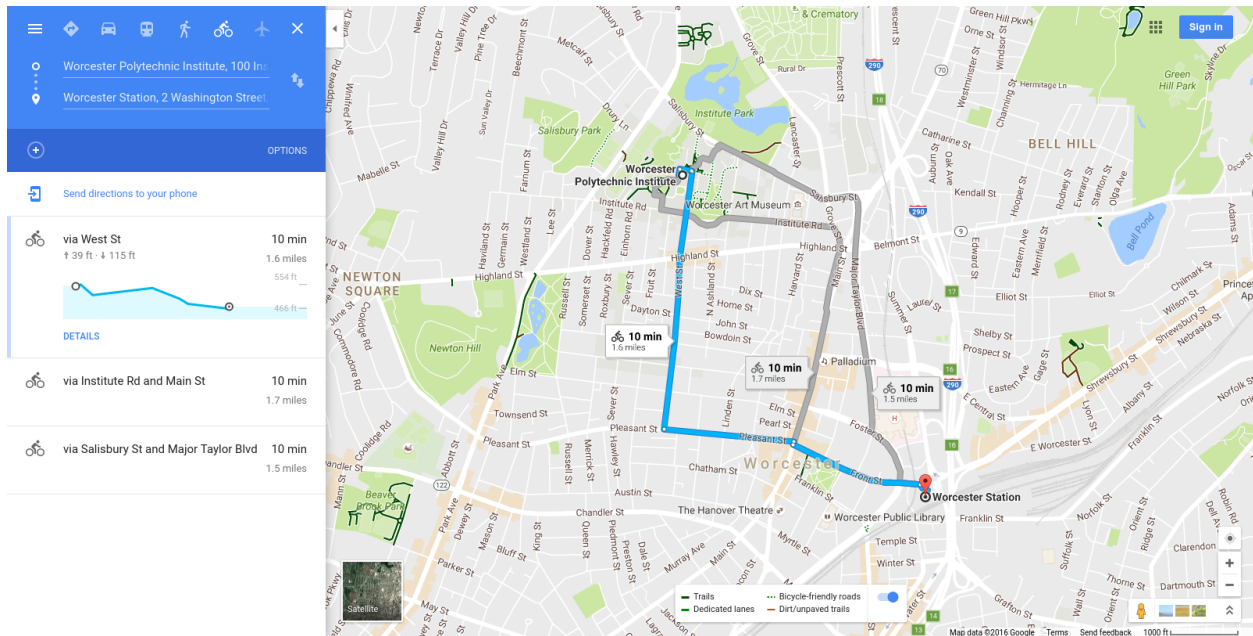


Figure 3: Sample biking directions between WPI and Union Station (Google Maps)

However, there are a few things that Google Maps doesn't currently do that people may find desirable:

- Call out places where there are unusually large numbers of accidents, or roads containing multiple potholes, narrow lanes, and high speeds
- Allow for people to customize their results, e.g. by prioritizing speed over terrain (although by returning several possible paths, they do allow for some selection)
- Show or track bike parking¹

Some of this information can be found in other places. For instance, the MassDOT Open Data portal provides a variety of standard-format map data, including information such as the location of bike and pedestrian accidents (Massachusetts Department of Transportation, n.d.). However, while there even exists a data layer showing the location of bike trails in Massachusetts (Massachusetts Office of Geographic Information, n.d.), there do not exist any maps detailing the location of bike lanes, places with bike parking, etc. Furthermore, the maps of bicycle and pedestrian accident locations are from 2013, making them slightly out of date.

With regards to bike parking, the bike share program IQP for WPI did make a map of the bike racks on campus (Ackerman & Colfer, 2015, p. 35), but did not look off-campus. The City of Worcester is running a Bike Rack project to get more bike parking built around the city by subsidizing businesses' building of bike parking (Bike Rack Project, 2016). The city will likely have a list of where all these new bike racks are, and may have a census of bike racks on public land (e.g., at public transit stops or at City Hall, parks, the city library, etc.). However, they do not keep track of what private

¹ Seen as desirable per (Daniska & Santley, 2016)

businesses/organizations have bike racks, so people will not know where to park their bike when going shopping or visiting any private business.

Challenges Bicyclists Face

There are many challenges that arise while bicycling, some of which may serve as an inconvenience to bicyclists and/or dissuade prospective bicyclists. This section will break down some of these obstacles and discuss their impact on bicyclists.

Worcester's Topography

Worcester is known to be a hilly city, which makes it difficult to bike around the city. A look at a topographical map will demonstrate that WPI and the surrounding area includes many noticeable elevation changes. These hills present a challenge to some bicyclists and may even dissuade some people from bicycling entirely. In a previous study about a bicycle share program in Worcester, student and faculty members of WPI were interviewed with all mentioning hills as one of the challenges of biking in Worcester. (Ackerman and Colfer, 2015).

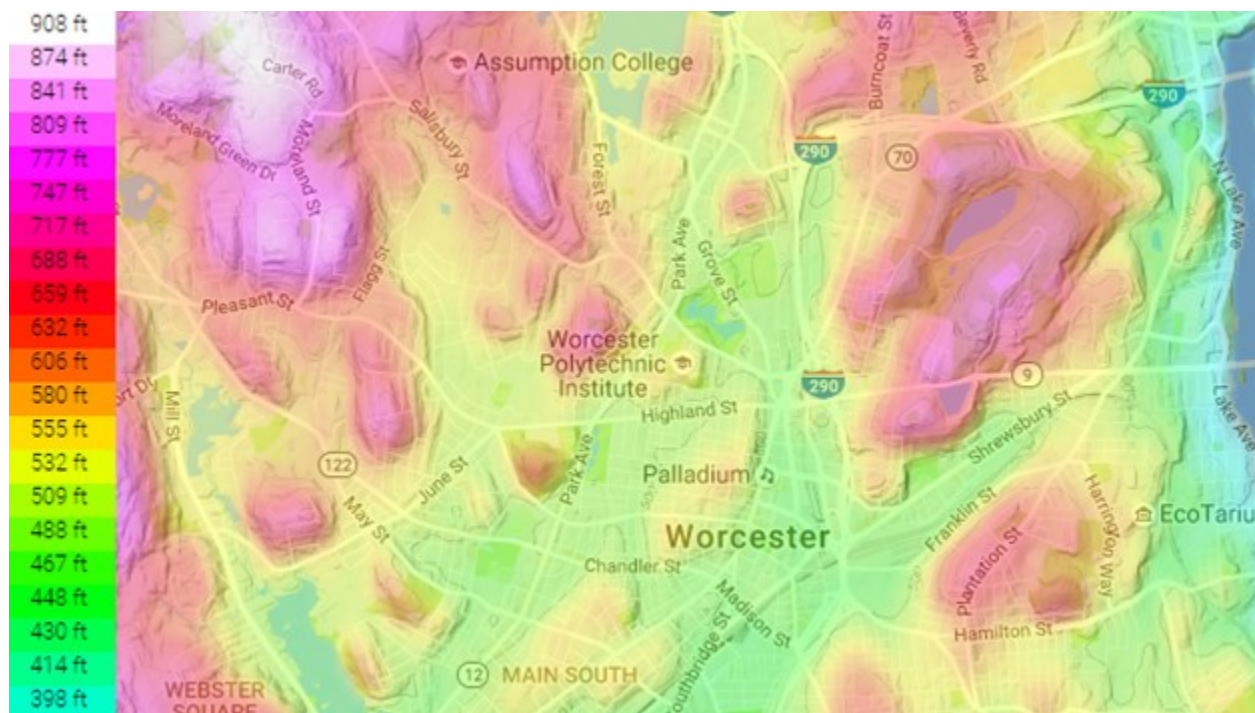


Figure 4: Topographical map of Worcester, Massachusetts (Topographic Map of Worcester, 2016)

However, a hilly terrain does not have to be a major impediment, as we can see by looking at Portland, Oregon. Portland is a hillier than average city (Pierce & Kolden, 2015). Despite its hills, Portland is also known as one of the best U.S. cities for bicycling (Dille, 2017). A study in Portland, Oregon found that 30% of prospective cyclists in the area saw hills as a barrier to cycling, indicating that while hills represent an obstacle for many cyclists, the presence of hills does not prevent the city from being bicycle friendly (Dill & Voros, 2007). The City of Portland also offers various resources for bikers, making the idea of bicycling for transportation more enticing than what Worcester currently advertises. The Portland Bureau of Transportation works to make bicycling an integral part of daily life with three primary approaches: planning, implementing, and maintaining a bikeway network; providing secure

bicycle parking; and educating people about the role of bicycle transportation (Transportation, 2016). Portland offer various bike maps that include bike parking locations, bike lanes, and new bike crosswalks for bikes only. They also offer information on bicycle parking such as locker locations, rack locations, rack sizes, and a resource to report an abandoned bicycle that might have been locked on a rack for an extended period. Making bikers feel safe while riding can be gained with education of the rider. Portland offers information on family biking, bike rack laws, riding laws, and biking communities throughout the city (Transportation, 2016). With all of the available resources Portland's topography is not seen as a deterrent from riding in the city.

Like Portland, Worcester has hilly terrain. Comparing the topographical map of Worcester in Figure 4 (above) to the topographical map of Portland in Figure 5, Worcester appears to be at least as hilly as Portland. This suggests that, like Portland, Worcester could encourage more bicycling and reduce the impact of hills by providing more resources to educate cyclists. However, because it does appear that Worcester is hillier than Portland, it is likely the case that Worcester will have to work harder than Portland to reach similar levels of bike friendliness.

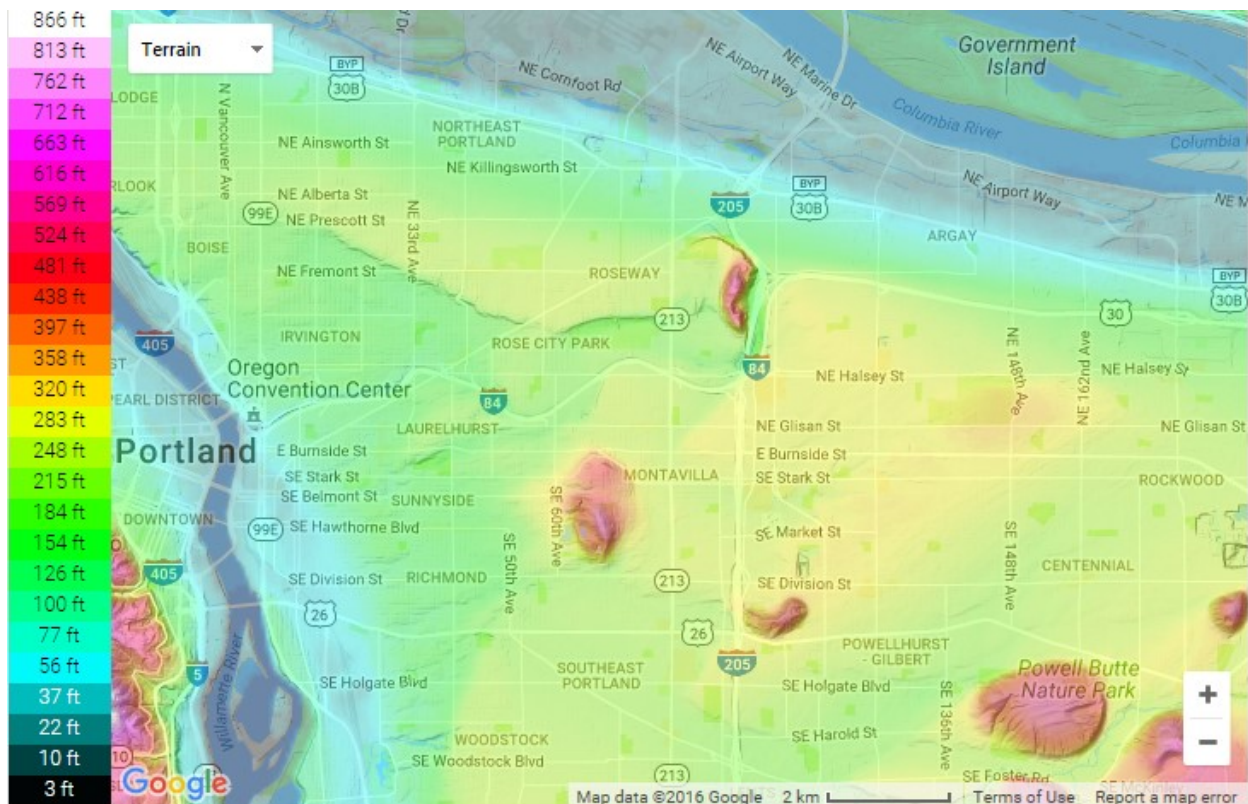


Figure 5: Topographic Map of Portland, OR

Road Safety

One of the main obstacles to bicycling in a city is concern for safety. 52% of American adults interviewed by Breakaway Research Group in 2015 said they were worried about being hit by a motor vehicle while bicycling. A demographic breakdown by region of the results can be seen below.

Approximately 59% of the Northeast population said that they are worried about being hit by a vehicle when riding a bike.

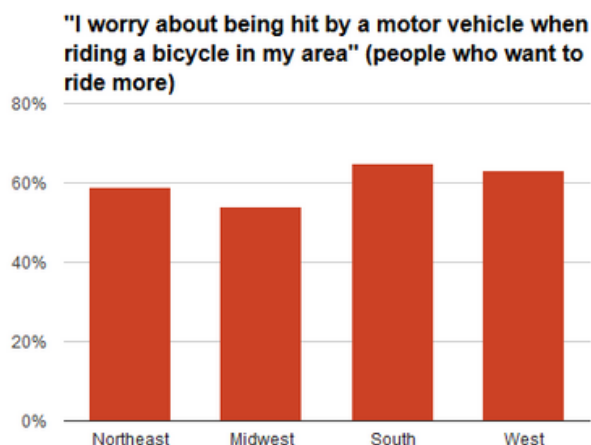


Figure 6: Bar chart from the U.S. Bicycling Participation Benchmarking Study Report which illustrates the percentage of people, by region, who are afraid of being hit by a car while bicycling (Breakaway Research Group, 2015).

52% of people nationwide worried about getting hit by a motorist while riding a bike, and cyclists in Worcester have a good reason for this fear, since Worcester has a higher number of accidents compared to most cities in the nation. Forbes listed Worcester as one of the worst cities to drive in, using numbers produced by Allstate that indicate that Worcester drivers have an accident every 4.3 years, making them 134.8% more likely to crash their cars than the average American (Gorzelyany, 2014). This suggests that any potential resource should include information on how to minimize risk while bicycling in the city.

Limited Number of Bike Lanes

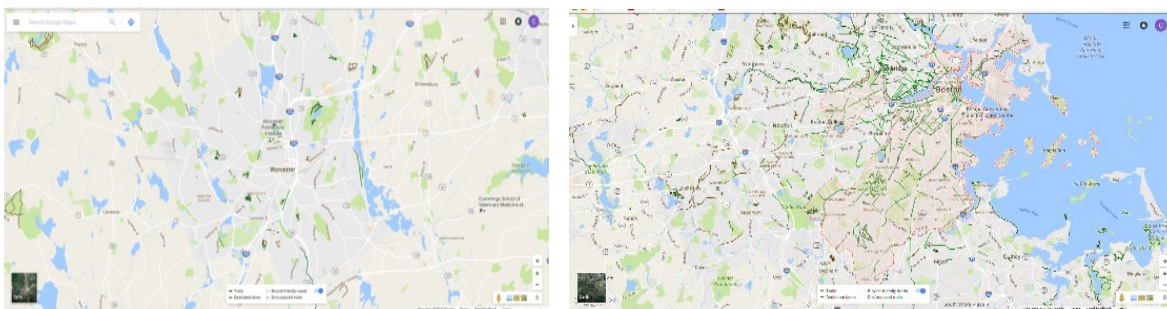


Figure 7: Comparison of Worcester (left) bike lanes on Google Maps compared to that of Boston (right)

Denmark, one of the leading countries in biking as a main source of transportation, has 1350 km of separated bike lanes containing air pumps every kilometer and signage similar to vehicle highways (Denmark, n.d.). With safety being a major concern for most cyclists, bike lanes are a major safety advantage for cyclists. Bike lanes entitle cyclists to a part of the road, and therefore make it safer for them to ride on the road. Shown in Figure 4, there are not many bike lanes that are mapped in the Worcester area compared to Boston—likely because there are not many bike lanes in Worcester to

begin with (Daniska & Santley, 2016). The bike lanes that are available in Worcester are poorly signed, reducing their visibility and the likelihood that they will actually be used. The lack of bike lanes reduces the safety of biking (Teschke, et al., 2012), whereas having bike lanes allows bikes and vehicles to have their own designated lanes safely separated. Also, the lack of any more nuanced information, such as roads where it may be safe to bike despite the lack of a bike lanes, further limits inexperienced riders' ability to make informed route choices.

Other Challenges

Other challenges that bicyclists face include:

Bike Theft: The possibility of having their bike stolen may deter people from commuting via bike. Bike theft is very prominent at colleges; a four-year college student has a 53% chance of being a victim of bicycle theft (National Bike Registry, n.d.). However, people can make it more difficult for a thief to steal their bike by using the National Bike Registry's suggested methods of locking a bike (National Bike Registry, n.d.).

Lack of Awareness: People may be unwilling to commute via bicycle if they believe that there is a lack of support available. Ackerman and Colfer found that some WPI students had the perception that there was a lack of resources for bicyclists (Ackerman & Colfer, 2015, p. 19).

Available Resources for Bicyclists in Worcester

Worcester has resources available to it to combat some of the aforementioned challenges that bicyclists face. Though these resources may not be widely known, they do exist. These resources each address specific issues, but no one resource addresses all the challenges that a bicyclist may face.

League of American Bicyclists

The League of American Bicyclists is a nationwide non-profit organization which seeks to promote a more bike friendly America. Their website, www.bikeleague.org, features a map which contains information such as bicycle clubs, advocacy organizations, bike shops, and other information a bicyclist may find helpful. The organization also has a bicycle education program called BikeEd. This educational program has multiple skill levels for children and up to adults that provides information from bike maintenance and how to shift to what to wear and how to stay comfortable when riding.

National Bike Registry

The National Bike Registry (NBR) has been working with law enforcement since 1984 to return stolen bicycles to their original owners. The NBR maintains a database of bicycle serial numbers, which the law enforcement can use to identify stolen bikes that they recover. People can register their bike in this database for \$10/10 years, \$25/30 years, or \$25/10 years for a family with five bikes. The NBR also offers tip on what lock to use and how to properly lock a bicycle to avoid theft.

Worcester Earn-a-Bike

Worcester Earn-a-Bike allows the opportunity to receive a free bicycle. Worcester Earn-a-Bike is a nonprofit bicycle repair shop whose goal is to educate people on proper bike maintenance and allow them to earn a bicycle free of charge. After 10 hours of volunteering at the shop, the volunteer will receive a free bicycle. Volunteer work includes organizing parts, building bicycles, and generally helping around the store (Worcester Earn-A-Bike, n.d.).

Worcester Earn-a-Bike also offers an Open Shop and another program called Learn-a-Bike. During Open shop hours, anyone can use the bike stands and an array of tools. Volunteers at Worcester Earn-a-Bike will also teach basic bike maintenance and more complicated bike maintenance. Part of their Learn-a-Bike program is to teach basic bike maintenance and more complicated maintenance that they might not have time to teach during Open Shop. They ask for a small donation for using the open shop or the Learn-a-Bike program.

Elements of Digital Mapping Resources

Best College Values, an organization that aids students in finding resources they need to make beneficial decisions in their lives, conducted research in which they compiled a list of the top 40 most bike friendly college campuses in the U.S. (The 40 Top Bike Friendly Campuses, 2016). The ranking was based upon the following factors: campus bike awareness, campus bicycle clubs/teams, campus education on bicycling, ease of biking on campus, and miles of bike trails on campus. Common amongst many of the ranked colleges was that they used websites/maps to inform students of things such as: bike rack locations, rental locations, repair stations, bike shops, and bike routes.

Detailed Mapping

For reliable and informative digital biking resource the community needs a biking infrastructure containing: bike parking, bike lanes, signage, biking related organizations, and a way of getting this information easily. Many organizations create mapping websites that the community can use to access various biking information such as bike lanes, bike racks, and areas of elevation change. Some examples of these resources are described in the following sections.

Cycling Routes

The English website, Cycle.Travel, provides cyclists information about cycling in various cities in England. The website provides a map of each city with the cycling routes highlighted, information for getting around, a forum that can be used to ask questions about cycling in certain cities, bike shops, and where destinations and routes of interest are located. Cycle.Travel provides information that a new cyclist who has never been to a given city might find useful. The information provided by the website may help a cyclist to determine where scenic rides might be and where cycling roads are located.

The site includes the most popular cycling routes, as well as some of the challenges cycling through the city. For example, in Worcester, England, it can be difficult make one's way from one side of the city to the other because of hills and due to the cars racing by (Worcester Cycling Guide with maps and routes, n.d.). The site provides information on how to stay away from traffic and to make your way from one side of the city to the next.

A map that provides directions for cyclists is the centerpiece of the website. For this feature, the user picks a start and end and the map will find a route that avoids roads without bike lanes. The map also allows the user to pick a starting location and then have the map suggest a possible ride. The suggested ride prioritizes bike lanes and trails to increase safety and comfort of the bicyclist.

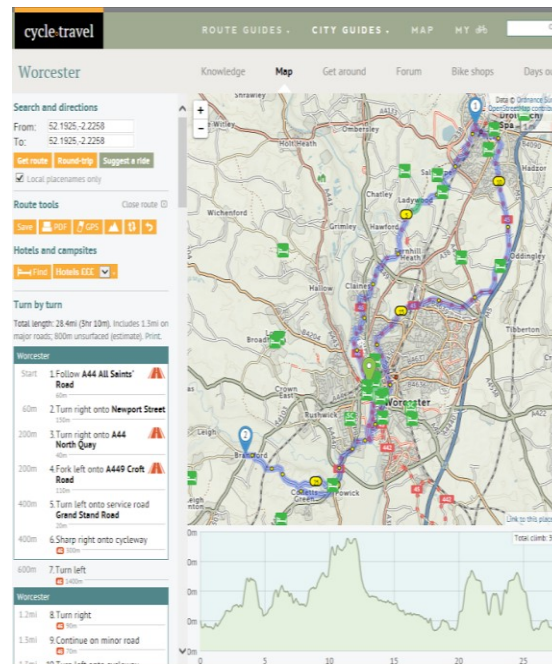


Figure 8: Cycle.Travel Map of road and bike lanes in the city of Worcester in England (Worcester Cycling Guide with maps and routes, n.d.).

Another section of the website provides routes to get from one major parts of the city to other. There is also a forum on the website that allows cyclists can ask questions to gain more insight about cycling through that specific city and alert other cyclists about a hazard on a route.

Anyone who is commuting to work by bicycle, or just riding around the city for enjoyment will eventually need to go to a bike shop to get replacement parts and possibly a tune up. Cycle.Travel has mapped of all the bike shops in the specific city. The website also has a section, titled “Days out” which has an index of some scenic routes around the city, for any recreational riders who may be new to the city and is looking to go on a scenic ride. Finding a route around the city that is safe and scenic can present challenges for someone who has little to no knowledge about the city. Cycle.Travel seems to provide useful information for a bicyclist who has never been to the city and is looking to get information to plan a safe and efficient around the city.

Indicating Elevation

Flattest Route is an open source web app that helps bicyclists minimize elevation changes during their trips (Weinstock, 2013). The app utilizes Google maps to find the flattest route between two specified points. The app also provides a slope chart that informs the rider of their elevation throughout the entirety of the trip; this allows them to gauge the difficulty of the trip. This app has great appeal amongst commuting bicyclists who seek the easiest path while going from point A to point B. An example of the app in use can be seen below.



Figure 9: Sample directions between WPI and Union station using Flattest Route

Location of Bike Utilities

The need for a single resource which clearly and conveniently lays out all the existing resources available to a bicyclist was fulfilled by RackIt. At the University of Kansas, graduate student Jay Decker created RackIt to help student bicyclists find places to park their bike on campus (Farber, 2013). RackIt utilizes Google maps and satellite imagery to provide a visualization of the location of all the bike racks on the university's campus. Many of the students who have used this app have mentioned that there were numerous bike rack locations that they never knew existed.

Locations of Safest Routes

Tacoma, Washington's map, seen in Figure 10 below, contains information on the speed/volume of traffic on certain roads. Roads are color coded in order to show which roads will most likely have lower traffic/lower speed limits. For example, green roads are paved trails, which would be the safest because cars are restricted from driving on these paths. The map enables cyclists to choose roads that limit the volume of traffic and the speed of traffic, on the roads that they are travelling on. The map also makes note of where bike lanes, bike boulevards, shared lanes and other roads are.

Looking at this map makes it very easy to choose a route that will minimize the amount of riding in traffic, by taking safer bike paths. A user of this map will be able to choose safer/ low traffic roads by visually seeing them on a map and then planning accordingly, depending on the user's preferences.

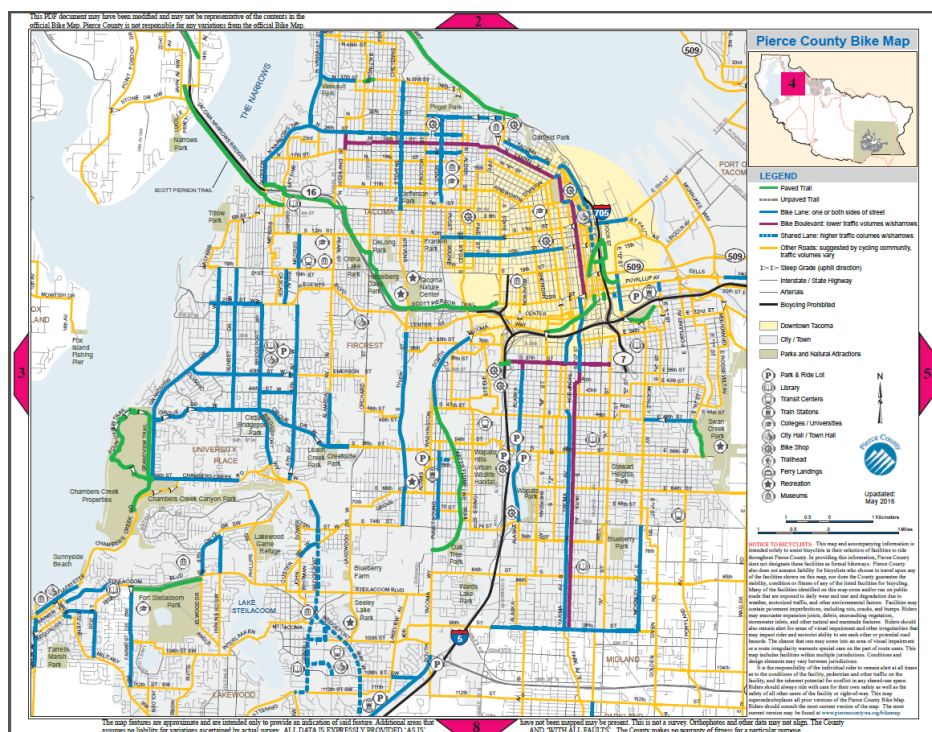


Figure 10: A Section of map of Tacoma, WA Bike Paths (Pierce County, n.d.).

The map has information about bike boulevards. A bike boulevard is defined as a road with lower traffic volume with sharrows or shared lane markings (National Association of City Transportation Officials, n.d.) on a bike boulevard would make the road more enjoyable and safer to travel on than a shared lane. A shared lane, as defined in this map, is a road with (Pierce County, n.d.).

As a way of trying to promote the many benefits of cycling, the city of Tacoma, Washington, has provided cyclists a digital feature allowing user to report infrastructure problems. The website makes it easy for cyclists to find information about different problems that might arise while riding in the city. For example, if you find that someone has blocked a bike lane, then there is a contact for this. With these contacts, it makes it very easy to report a problem, so that it can be fixed.

Providing Multiple Directions for a Destination

Ride The City provides different routes based on destination and route safety. This website is not specific to Boston, and includes maps of other major cities around the world. Ride The City provides information about a chosen route, such as the total distance of the route, the estimated time that the route will take, and the elevation gain of the route. There is also a list of the turn-by-turn directions which makes note of when you will be riding on roads with bike lanes, or when you will be riding on a bike path. The directions make use of pins on the map, which allow the user to see where bike shares, bike shops, and other points of interest are located.

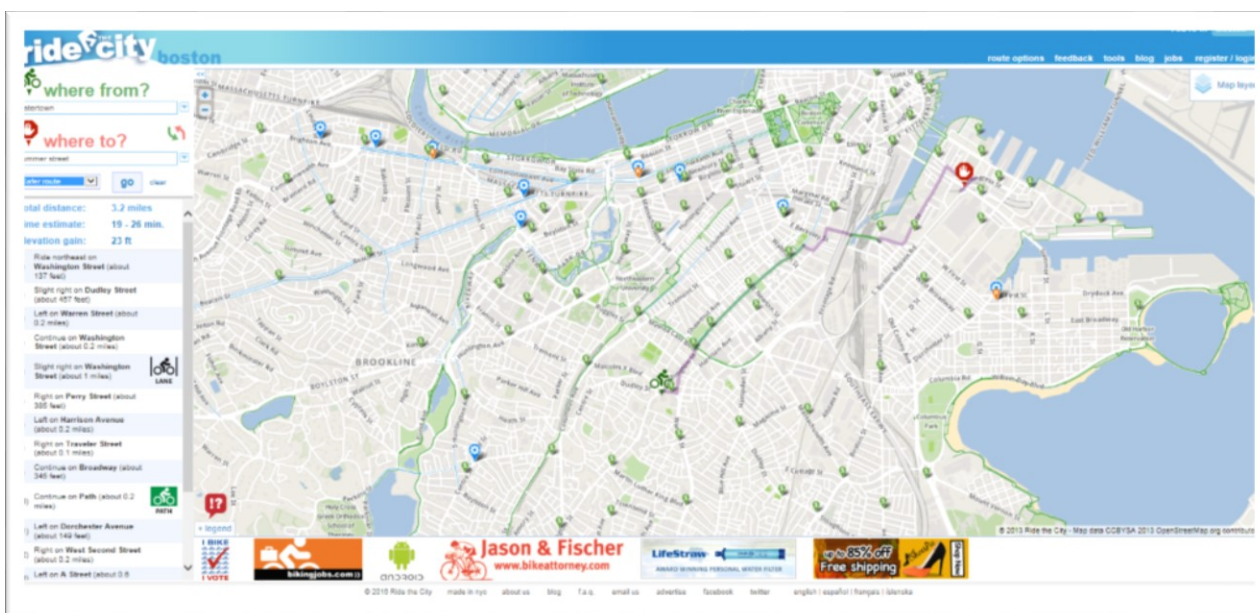


Figure 11: Sample route created in Ride the City Boston (Ride The City--Boston, n.d.)

Other features of the mapping website include the option of choosing a direct, safe, or safer route. If a cyclist is more worried about how direct their route is, then they can weight this more and disregard how safe the route may be. Other cyclists may be more worried about the safety of the route and so the map can prioritize safety and the directness of the route will not be as heavily weighted. The safest route will encourage use of bike lanes and paths. For someone who is more comfortable riding through the city and is looking for a more direct route, the site will route them on a more direct route, which might not necessarily be as safe. Once a user has ridden the route they can then rate the route on the website and then give any comments on the route. Comments can include what they liked about the route and what they disliked about the route. This information is then used to help to make future routes safer and better (Ride The City--Boston, n.d.). Having this sort of resource can help someone who knows nothing about the available paths and bike lanes to choose a route, making the greatest use of bike lanes and bike paths to ensure that they are on a route that will, in theory, be the safest and most enjoyable for them.

Promoting Biking

Digital resources have many benefits for cyclists, one being it allows them possess more information with regards to cycling safety. Boston's mayor, Marty Walsh, has a goal to make Boston a "world class bicycling city, inviting for residents and visitors alike." (City of Boston, n.d.) In order to make the city safer and more inviting for bicyclists, the City created an organization called BostonBikes, which is working to create resources for people that are interested in biking but might not know where to start or how to safely make their way around the city. Bostonbikes.org provides tips, routes, and classes to help anyone become a more proficient rider.

One of the resources that the organization provides is a map of routes, which would be useful for people that are unfamiliar with the city (City of Boston, n.d.). The map shown in Figure 12, provides a

way for someone living in one of these outlying suburbs to find a good route into the city. Boston Bikes also makes some suggestions for ways to map a bike route, including Google Maps and Ride the City.

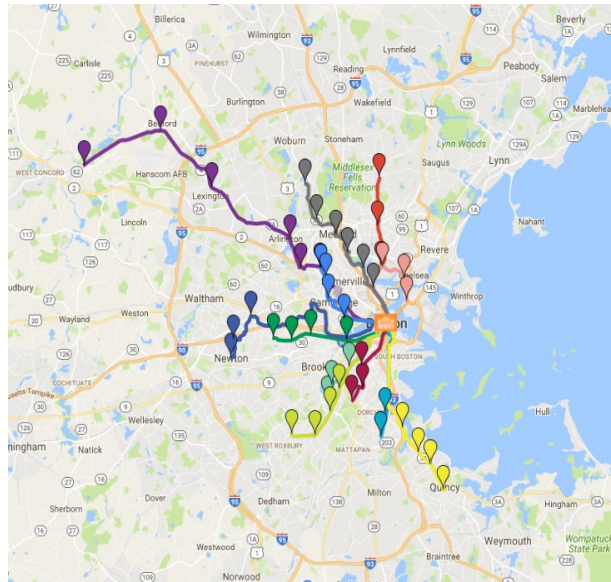


Figure 12 Map of Best Routes to Get into Boston from Outlying Communities (City of Boston, n.d.)

My City Bikes: Phoenix is a digital app that was created for the residents of Phoenix and the surrounding areas in Arizona (Phoenix Bikes App, n.d.). This is a free app intended to provide information to both those who are new to the region and existing bicyclists who may be looking for more information. The app includes bike lane locations, information on bike maintenance and repair, safety recommendations, and some route suggestions for recreational purposes.

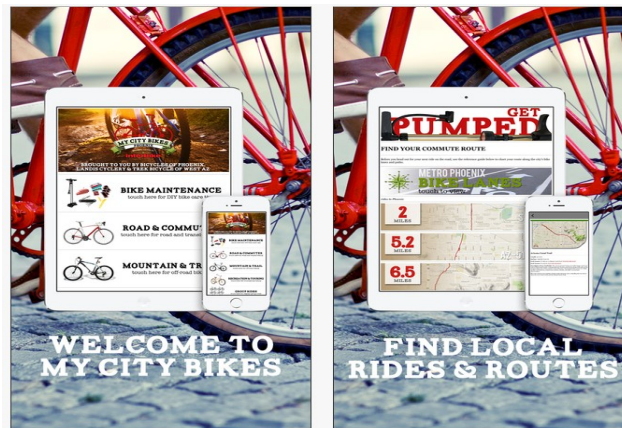


Figure 13 My City Bikes: Phoenix, (Phoenix Bikes App, n.d.)

CHAPTER 3: METHODOLOGY

To create a digital resource for Worcester bicyclists and potential cyclists, we took the following steps:

- Determined the needs of the stakeholders
- Obtained the data that will be used on the website, such as bike lane locations and topographical information
- Incorporated data and suggestions into the website.
- Got feedback on the website to make tweaks and pass on advice to future maintainers of the website

Determining What Information and Features Users Need

To build a digital resource, we must know what it is that people want in the app. As such, we generated a list of (a) what features should be included in the digital resource and (b) what information needs to be collected to include in the digital resource.

First, we talked with various stakeholders in the Worcester community about what already exists and what they need in a mapping system. As we talked with stakeholders, we learned about what resources already existed, what people wanted in the app, where we could find data to put in the app, and built relations with the bicycling community. To accomplish this, we talked to:

- The **Central Massachusetts Regional Planning Commission (CMRPC)**, which handles transportation planning in Worcester, especially for bicycles.
- **WalkBike Worcester**, an advocacy group that is tied well into the biking community of Worcester. We discovered what exactly to include in our resource, and received information on already existing biking resources in Worcester.
- **Local bike shops:** We attempted to contact all the bike shops in Worcester (Landry's, Barney's, Fritz's, and Bikes and Life), and ended up actually talking to three (Landry's, Fritz's, and Bikes and Life)
- The **City of Worcester** planning department—Specifically, we talked to Steve Rolle, Director of Planning and Regulatory Services

We chose these organizations based on their involvement with the Worcester biking community and our ability to get in contact with them (for instance, we were unable to elicit replies from a couple of local bike shops). We also attempted to get in contact with the people who run the *cycle.travel* website to see if they had any advice about building this sort of bicycling resource and if they might be able to help us in any way, given that their website was very similar to what we hoped to create. Unfortunately, despite multiple attempts at contact we were unable to reach them. Getting suggestions from someone who had implemented a similar resource in another city would have been a valuable perspective that, unfortunately, we did not get.

Before talking with each organization, we prepared a list of questions based on what we wanted to find out from the organization (e.g., for the City and for CMRPC, we added some focus on what

official resources might be available). The details of what we asked each organization can be found in Appendix B.

After discussions with the various organizations, we created a list of desirable features for the online resource, based on what people had supported—this includes both things that, when asked about, people generally supported, as well some things that multiple people brought up without our asking specifically:

- Bike rack and lane locations: This was brought up by most people we talked to; CMRPC was particularly interested, as they are currently working on setting up more bike racks around the city and if they knew where existing ones were, that might help their ability to choose where to put up new racks.
- Traffic indications on maps
- Road dimensions
 - Road width, with or without sidewalk, with or without vehicle parking along road
- Bicycle maintenance tips
- Locations of bike friendly businesses: Multiple people suggested that we might include lists of businesses around the City which are particularly bike friendly, even without us specifically asking them if they thought it was a good idea.
- Library of biking community contacts: In addition to being mentioned several times, we also figured that, since we had already gone to the trouble of locating the local community groups, the inclusion of a list of local organizations would be desirable.
- Where to buy used and new bikes/Where to get bikes fixed: This was mentioned in particular by the bike shops, which noted that they commonly had college students come in and not realize that used bikes might be available for relatively cheap.
- Mapping system that generates biking route from point A to B
- Topographic information (i.e., locations of hills)
- Dangerous area indicators, including intersections to approach with caution
- Most efficient biking routes
 - Best routes to colleges (brought up specifically by one bike shop)
 - Getting through city: The bike shops and people at WalkBike Worcester both brought up the possibility of including information about good routes for getting around particularly bad roads in the city.

For the most part, different groups seemed to generally be in agreement about which features were desirable, with the most common suggestions having to do with identifying good and bad roads for biking on so that people could more easily route themselves around the city.

Some of the items in the above list are also slightly influenced by what we saw in online resources for other cities:

- Most other resources included information on where to find local bike shops
- In mapping systems (particularly cycle.travel and flattestroute.com), showing hills along a route is a common feature

- Most resources attempt to indicate the locations of bike lanes and trails
- Cycle.travel claims to have done their routing algorithm in such a way as to avoid bad turns (e.g., left turns across busy roads) and other types of inconvenient intersections

Once we determined the features that we wanted, we retrieved data for the features. This will be discussed in the following section.

Retrieving Data

To build the digital resource, we required information, such as bike lane and parking information. This data was then used in the creation of the resource.

When collecting the data, we relied on (a) Google Maps data, (b) crowdsourcing/direct data collection by us where data is not as readily available, and (c) government sources. Where possible, we attempted to obtain data in digital, pre-prepared formats so that we could simply use or write a computer script to put all the data into the map, rather than inputting it all by hand. The data that was available through Google Maps was even simpler to integrate, considering as we used Google Maps and so little to no integration was required to get all the data in a single place. Examples of common digital data formats include:

- OpenStreetMap XML or PBF formats, for which there are open source tools for reading the data
- Simple text files with lists of data (for instance, topographical data with latitude/longitude and elevation)
- Various ArcGIS formats, which is a common format for geographic data
- KML, a XML format originally developed for google earth support and now more common for any sort of geographic data

For all the data, we had the following preferences:

- Complete and current data, so that the digital resource is up-to-date and helpful.
- Readily updatable. While some features, such as the location of the roads, will not change often, information such as bike parking locations can change rapidly.
- Easily gathered; we do not have the resources to launch a city-wide survey of bike parking locations. For some things, such as bike parking, where there simply is no authoritative source, we built a crowd-sourcing feature into our map to allow anyone to contribute to the data.

We sought the following specific data for Worcester. This list is based on the feedback and suggestions we got when interviewing various groups about what was needed in an online bicycling resource:

Bike lane, trail, and sharrow locations: Google Maps does have information on bike lanes and trails in Worcester, but it is not complete. A complete list of where the bike lanes are in Worcester is not publicly available. Contact was made with CMRPC to locate a list, only to find that there are no complete records. After being pointed in the direction of the city's Planning and Regulatory Services, we contacted Stephen Rolle, Assistant Chief Development Officer of Planning & Regulatory Services Division in Worcester, set up a meeting where he showed us the locations of most of the bike lanes and sharrows in the city by hand.

Accident statistics: We used this data to determine which intersections should be approached with extra caution. The raw numbers were available online through the MassDOT's online Geographic Information System (GIS), although the statistics are all from 2013 or earlier and may not reflect any newer changes to traffic patterns the accident numbers, relative to traffic flow and volume. The data obtained was a list of the top 250 intersections in Massachusetts with the most accidents. The list was taken and condensed down to Worcester intersections only, seen in . The left column shows the state-wide rank of the intersection. This information was then used to indicate dangerous areas on the websites mapping system.

Table 1: Intersections with the Most Accidents in Worcester, MA

Rank	Town	RPA	MassDOT District	Street 1	Route 1	Street 2	Route 2	Total Crashes	EPDO Crashes	Fatal Crashes	Injury Crashes	PDO & Non Reported Crashes
20	WORCESTER	CMRP	3	SOUTHBRIDGE STREET		HAMMOND STREET		81	173	0	23	58
24	WORCESTER	CMRP	3	PARK AVENUE	9	HIGHLAND STREET		83	167	0	21	62
25	WORCESTER	CMRP	3	HIGHLAND STREET (LINCOLN SQ)	9	MAIN STREET		88	164	0	19	63
28	WORCESTER	CMRP	3	BELMONT STREET	9	LINCOLN STREET		85	161	0	19	66
33	WORCESTER	CMRP	3	LINCOLN STREET	70	MARSH AVENUE		72	156	0	21	51
34	WORCESTER	CMRP	3	HIGHLAND STREET	9	MURRAY STREET		71	155	0	21	50
36	WORCESTER	CMRP	3	CHANDLER STREET	122	MURRAY AVENUE		57	153	0	24	33
50	WORCESTER	CMRP	3	PARK AVENUE	9	PLEASANT STREET		78	142	0	16	62
63	WORCESTER	CMRP	3	MAIN STREET	9	MILL STREET	12	58	134	0	19	39
65	WORCESTER	CMRP	3	BELMONT STREET	9	PLANTATION STREET		65	133	0	17	48
71	WORCESTER	CMRP	3	LINCOLN STREET	70	MELROSE STREET		46	131	1	19	26
95	WORCESTER	CMRP	3	CHANDLER STREET	122	PIEDMONT STREET		40	120	0	20	20
121	WORCESTER	CMRP	3	GRAFTON STREET	122	HAMILTON STREET		46	114	0	17	29
121	WORCESTER	CMRP	3	MAIN STREET	9	PARK AVENUE		46	114	0	17	29
125	WORCESTER	CMRP	3	HIGHLAND STREET	9	MAIN STREET		53	113	0	15	38
130	WORCESTER	CMRP	3	PROVIDENCE STREET	122A	MILLBURY STREET		47	111	0	16	31
138	WORCESTER	CMRP	3	EAST CENTRAL STREET		SUMMER STREET		49	109	0	15	34
142	WORCESTER	CMRP	3	HARDING STREET	122	HARRISON STREET		44	108	0	16	28
143	WORCESTER	CMRP	3	LINCOLN STREET	70	COUNTRY CLUB BOULEVARD		55	107	0	13	42
161	WORCESTER	CMRP	3	BELMONT STREET	9	LAKE AVENUE NORTH		44	104	0	15	29
169	WORCESTER	CMRP	3	MAIN STREET		CHANDLER STREET	122	45	101	0	14	31
169	WORCESTER	CMRP	3	GRAFTON STREET	122	MENDON STREET		37	101	0	16	21
184	WORCESTER	CMRP	3	SOUTHWEST CUTOFF	20	GREENWOOD STREET		46	98	0	13	33
184	WORCESTER	CMRP	3	PARK AVENUE	9	MAYWOOD STREET		39	99	0	15	24
207	WORCESTER	CMRP	3	MAIN STREET	9	KING STREET		35	95	0	15	20

Topographical and Road Location: Google Maps has complete topographical data, as well as essentially complete data on where all the existing roads and thoroughfares are. Since we did use Google Maps, we did not need to specifically acquire this data. If we had needed to acquire it ourselves, there is road data available through the MassDOT GIS system and topographical data available through the MassGIS system. Data on the locations of various roads can also be found in the OpenStreetMap project, although that data is mostly sourced from the MassDOT GIS system.

The following pieces of information were more difficult to find official sources on. Thus, we relied primarily on crowdsourcing or identifying an entity that can be charged with this data collection. For crowdsourcing, the website's mapping systems interface allows any authorized user to contribute to the map, such as by adding any bike racks that they might know of.

Bike parking: Dedicated bike parking is important for cyclists because it gives them a convenient place to lock their bike to prevent it from getting stolen. CMRPC did not have information bike parking infrastructure (e.g., locations that have been funded with government money), and given that we wanted detailed locations of bike parking, we instead had to rely on less-official channels. Initially, we manually looked online and in person for bike parking locations. A previous WPI student project includes a map of bike parking on WPI's campus. Part of the data retrieval included locating and examining these maps. However, to be sustainable, this information must be updatable, as we cannot perform a comprehensive survey, and the location of bike parking will change regularly. A crowdsourcing feature was added to the map that allows users to note where bike parking is; those locations can then be verified, added, or removed. To ensure that this feature is usable, we used it to input our initial data on bike parking. Locating bike parking information allows us to tell users where they can easily lock their bike and is also useful to agencies such as the CMRPC, who may use it for planning where to put future

bike parking. Businesses may be more inclined to install bike parking once they learn about the resource.

Bike shops/repair locations: Google Maps lists four bike shops in Worcester (Barney's Bicycle, Bikes and Life, Landry's Bicycles, and Fritz's Bicycle Shop). However, Google will list bike shops but not all organizations related to the biking community. For instance, the Worcester Earn-A-Bike project is not identifiable as a standard bike shop because it has no commercial purpose. These locations can be inserted manually, as can the opening of new bike shops (or an existing one closing/moving). Bike shop locations allow users to find where to go to get a bike serviced or where to go to purchase a new bike.

Retrieving Information from Worcester Cyclists

To have information beneficial for the digital resource, the team gathered input and information from Worcester cyclists. The team contacted and conducted interviews with Fritz's Bicycle Shop, Barney's Bicycle, and Bikes and Life. During the interviews questions about biking concerns in Worcester, digital resources available, and promoting biking in the city were asked. The owners of the bike shops also talked for the community, mentioning topics brought up by customers they have talked too:

- Riding in Worcester is very dangerous, especially when riding alongside cars where there are no bike lanes
- Avoiding major intersections is a priority for most riders
- Many bike shop customers weren't aware that used and refurbished bikes were available for sale

Complete notes and partial transcripts of the interviews were recorded and are in Appendix B.

Implementing the App

Implementation of the resource is the final component of the digital resource. To do this, we first determined a platform to use.

In determining what platform to use, we looked at existing resources that accomplish similar goals and considered what would be simplest and best for our purposes. The main considerations are:

- Ease of use for the user – The easier the resource is for a user to navigate the more willing they will be to using it
- Ease of programming/building – The easier the app is to build, the more likely it was that we would be able to complete it in our timeframe; the easier it is to maintain, the more likely it is that we could find an organization to maintain it in the future
- Any cost that may be associated with it – A more expensive resource would be more difficult to keep funded over time
- Accessibility – Creating a resource that is accessible to websites and mobile devices, both Android and iPhone. A website would be more widely accessible, but might be slightly harder to use on a mobile device. A mobile version of the website would help mitigate these issues.

Accessibility and ease of development were the primary considerations when determining the platform. We wanted the resource to be available to the entire community, whether you had an

Android/iPhone or no smart phone at all. Creating a website that is also mobile friendly allows us to have the largest accessibility to the community. Ease of development was critical to ensure that we could realistically complete the website within the given timeframe, while ensuring that future maintainers of the website could update and modify things with ease. Further discussion of future maintenance of the website is discussed in the “Future Maintenance of the Website” section.

App Platform Options

We determined that a mapping system was a required feature of the website, given the wide interest in being able to visualize the locations of bike racks, bike lanes, dangerous intersections/roads, etc. However, there are several different requirements for the map and several ways to implement it. The following is a list of features we adopted, based on the suggestions we got when collecting feedback from various groups, combined with our own judgement (for instance, most people we talked to did not worry too much about ease of development—that was our own concern):

- General ease of use for the user, such as making features of map easily distinguishable using a legend or key
- Ease of development
 - Simple and easy programing needed for development of the mapping system.
 - Includes ease of learning for future organizations to update map features.
- Ability to provide directions from point A to point B, with various features from the “Retrieving Information from Worcester Cyclists” section
- Ability to indicate useful information about Worcester that may not be as involved with getting directions themselves. Includes information such as community rides, bike shop contact information, bike maintenance, etc.
- Bike parking, bike shops, trail locations, etc.
- Indicators relevant to directions , such as accident-prone intersections

Based the investigated options, there were three general possibilities:

- Google Maps: Embed/link to raw Google Maps for biking directions, and build as much on top of it as we can (e.g. by displaying where bad roads are to allow people to manually adjust directions to avoid them)
- Spend lots of time on open source tools (using OSM (OpenStreetMap) as a basis) to try and make a highly-developed direction-finder for point A->B starting with existing implementations and add in anything else needed.
- Or, still use the open source tools, but don’t focus on giving excellent navigation directions. Rather, do a smaller amount of work on the existing tools to make sure they focus on making the interface clean and information-rich

Table 2: App Platform Options

Area	Google Maps	OSM--routing focus	OSM--information focus
User Friendliness	In most aspects, excellent (anything we add makes things more	Very functional, but not necessarily clean	Usable

	complicated and less friendly)		
Ease of development	Least, but still requires time and effort	Maximal; lots of work	Substantial amount of effort
Direction-finding	Good	Best	Adequate, but slightly worse than google maps
Other information	Would not allow high levels of customization, but can display arbitrary icons and lines on the map	Good, as we could customize markers and modify the source code to display things how we want	Good, as we could customize markers and modify the source code to display things how we want
Future-proofing	Poor--google maps API is not flexible enough to allow customization to the cartography of the map, the underlying data, or the manner in which directions are calculated	Good, as there is a fair amount of room for changing the algorithms that we might write	Good, as there is a fair amount of room for changing the algorithms that we might write

Two of these items deserve further discussion:

With regards to the ease of development, we had not assumed that the OSM options would take as much effort to develop as they did. Due to the steep learning curve involved with jumping into work in a whole new area (mapping systems) as well as the quantity of code and libraries involved, it turned out to be a substantial project. This resulted in us spending a large amount of time investigating OSM, making relatively slow progress, before we switched over to Google Maps.

Furthermore, we note that the Google Maps API option will be poor for future improvements to the website. With the open source option, there is a great deal more flexibility and potential for improvement. However, this also introduces a greater amount of complexity and leads to the issues above. With Google Maps, there is a moderate amount of flexibility for making something that looks appealing and does a simple job, but we would never be able to, for instance, alter the underlying routing algorithm to account for new bike accident statistics; the most we can do is display the information to the users and hope that they can process it all visually.

Overall, this led us to turn towards using Google Maps with the public Google Maps API to provide users the advantage of an existing, moderately sophisticated routing engine. However, we strongly advise that future iterations of the map consider switching to various open-source implementations, to allow for more sophisticated customization of the map.

Getting Feedback on the Website

After we completed the initial version of the website, we returned to some of the groups that we had talked to before building the website and asked for feedback so that we could both make useful improvements to the website as well as passing the feedback on to future maintainers of the website. In

choosing groups to talk to, we were interested in talking to both people who might be likely to use the website as well as people who might be involved in maintaining the website. With that in mind, we attempted to contact all the groups we had contacted earlier, as well as talking to the WPI Green Team, and ended up getting feedback from:

- **WPI Green Team:** We talked to the main person at the Green Team who was likely to get involved in maintaining the website.
- **WalkBike Worcester:** Although we did not get a chance to use one of the WalkBike Worcester monthly meetings to get feedback, we did get a chance to ask WalkBike Worcester members for feedback and they sent out a link to our website on their mailing list. We got several responses with general feedback on the website. These are both among the people most likely to use the website as well as those most likely to spread word of the website, due to their active involvement in the biking community.
- **Worcester Bike Shops:** We went around to the bike shops and asked for feedback on the website, for largely the same reasons as WalkBike Worcester. We went to the same bike shops as in our initial rounds (i.e., Fritz's, Barney's, and Bikes and Life)
- **General Website Users:** We got one spontaneous piece of feedback from a user who contacted us through the public contact form on the website.

Specific pieces of feedback can be found in Appendix C, and we summarize the results of the feedback here:

- Most people had trouble finding all of the features of the map—many people did not realize what certain colors meant, and most people did not realize that an anonymous user could add data to the map
 - Until we added the colors to the legend, people were not sure what the colors on the directions were (these colors refer to the steepness of the route)
- In general, most people liked the content on the website; there were a variety of suggestions for some specific content to be added, including the following. We added most of the suggestions, as there was relatively little cost to adding a bit of new content:
 - Some good videos that a reviewer was familiar with
 - Information on what to do after a bike is stolen
 - Suggestions about bike parking when no racks are available
- CMRPC made some suggestions about the organization of the tips and resources pages, which we implemented to make it easier for people to locate articles
- CMRPC also suggested adding a line type to the map where people could suggest locations for bike lanes, so that CMRPC could look at the suggestions and see where people want bike lanes
- A few different people (including CMRPC) suggested adding voting for locations and lines so that we could separate good and bad suggestions
- We received multiple suggestions for things we had already implemented, especially on the map, due to people not being able to easily identify all of the features of the map. We took these suggestions as an indication that we had done an inadequate job of making the features of the map clear

In general, we then implemented whatever suggestions we could in the time we had, prioritizing things that had been suggested more often or which came from more authoritative sources (this meant

prioritizing CMRPC, then bike shops and key WalkBike Worcester people, and then other people, tempered by our own impressions and opinions). Our recommendations as to which feedback should be prioritized by future maintainers of the website is included in the Recommendations section.

Future Maintenance of the Website

To ensure that the online resource is still useful after this project ends, we had to find an organization to maintain it. Ideally, such an organization would:

- Be involved with the Worcester cycling community to some extent, to ensure that they will be able to keep up to date with the cycling community's needs
- Have an interest in maintaining the website, so that they aren't inclined to simply let it simply become out of date as the data becomes less and less accurate over time
- Have the resources to maintain it over the course of multiple years

The two main possibilities for maintaining this were either a student group on WPI's campus (e.g., the Green team), as they would be able to maintain it over multiple years and would probably be interested in doing so, or a government organization such as the City of Worcester itself or CMRPC, which should have the means to maintain it, but we would have to make them interested.

We met with the WPI Green Team, and in addition to getting some feedback on the nearly completed website, they agreed to take over the maintenance of the website for the foreseeable future.

CHAPTER 4: DESIGN FEATURES

In the following chapter, we describe a website created to improve the bike-ability of Worcester. After identifying and categorizing information on biking in Worcester, mapping biking infrastructure, bike safety/maintenance, and providing information on the biking community, we came up with resources to assist bicyclists, and then included those resources in a publicly accessible website that we created.

The primary purposes of the website are twofold:

1. Collect useful information about bicycling in one central place (e.g., information on bike maintenance, taking bikes on public transit, etc.)
2. Augment the standard Google Maps biking directions by displaying additional information (e.g., bike rack locations, particularly dangerous roads) on the map to help users decide what routes to take when biking around Worcester.

Community Biking Needs

These are the broad needs identified from the various interviews with biking groups around Worcester and how we address them in the website.

Mapping Biking Infrastructure

Like many cities, Worcester has a complex road infrastructure, always under construction, lots of traffic throughout the day, and is very hilly, which can make it less safe for all riders. If cyclists know where to find various pieces of infrastructure, such as what roads/intersections to avoid, or where to go to park their bike, then they can more safely and easily navigate the city. In order to implement this, we display the information on the map itself (it does not affect the direction finding itself).

Furthermore, in order to get the data onto the map, there must be a way to easily edit the map and add the data. We implemented the ability for new data to easily be added onto the map.

Bicycling Advice and Information

Many of the comments from various bicycling organizations suggested including information on how to bike safely/perform maintenance/etc. In order to add this information, we organized information into categorized articles on the website and link to more detail information where available (e.g., including links to bike shop websites, or to more detailed articles about bike maintenance).

Digital Resource

After assessing the needs of the cycling community of Worcester, we decided that a mobile friendly website, "Worcester Biking Resources," containing all the resources would be an appropriate solution for the community. A broad overview of the website is provided here. For more detailed explanations of everything, see the User Manual for information on how to use the website, and the technical documentation for details on how individual pieces were programmed and implemented.

Website

Looking at the Home page in Figure 14, there are links to:

- An “About” page which describes information on what the purpose of the site is and who created it
- “Tips and Resources,” which contains the main content of the website, categorized into sections depending on what the content covers
 - These articles cover the topics requested by various groups when we were interviewing them
 - The links beneath the “Tips and Resources” refer to categories; there are multiple articles under each one
- A link to the “Map”
- A “Contact” form for the website

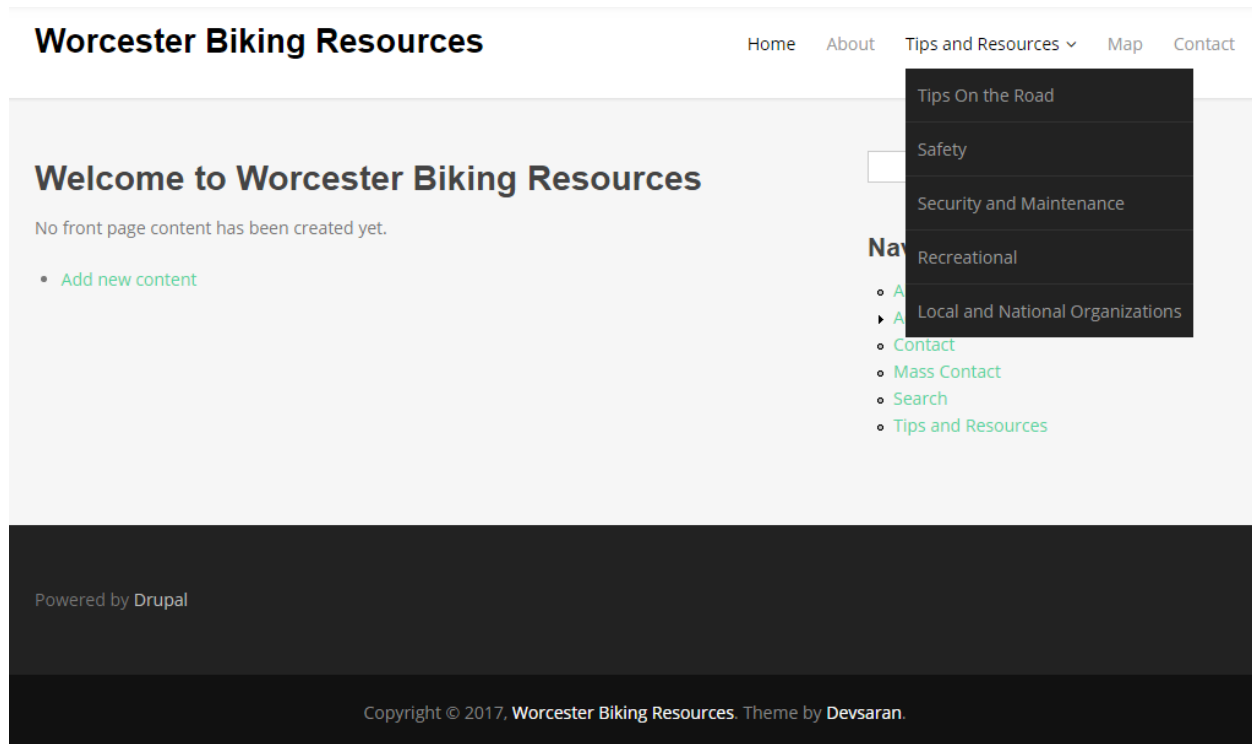


Figure 14: Home Page

When viewed on a mobile device, the format of the website adjusts to become more mobile friendly, to better accommodate users that may want to view the website on their phone, whether while biking or at home. This is accomplished by having installed a particular “theme” in the framework running the website (see the technical documentation for more information):

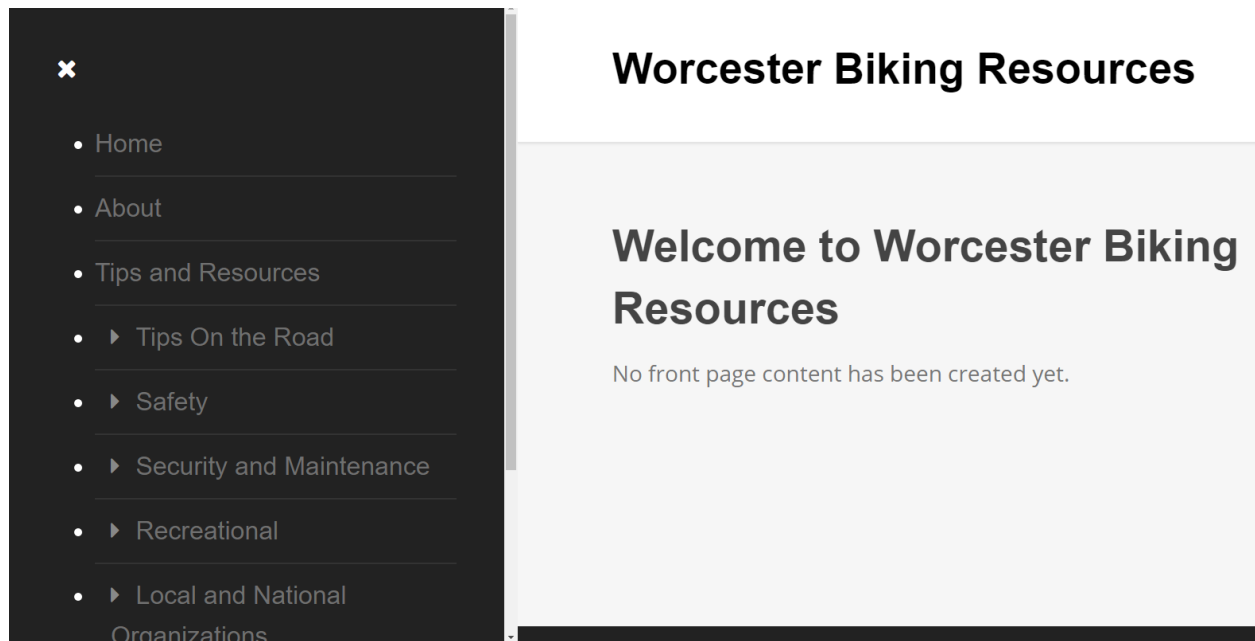


Figure 15: Mobile View of Homepage

Map

When the user clicks on the link to the map, the map in Figure 16 appears. Viewing the map, the user can see the various pieces of information that may be relevant to their ride, as determined from the feedback we got from the community (see the map legend for exactly which information we included). In order to get directions, the user can fill out to/from addresses and click “Directions” (directions are provided by Google Maps—we do not control the routing algorithm itself). In order to add markers/lines (e.g., the user knows a particularly bad intersection that should be avoided), the user can click on “Add Data” and add anything that falls under the “Lines” or “Markers” section of the legend. The exact types of lines and markers we show are based on the most commonly mentioned things from our early interviews. Additional types and styles of line/marker can be added with relative ease.

When directions are presented, information on the elevation along the route also appears (see Figure 17). The user can see the elevation change along the route both in a graph and in the coloring along the route. The user can also choose whether or not downhill slopes should be highlighted by selecting the “Show Downhill Slopes” option in the legend. The code for the elevation charts and display is originally from flattestroute.com, an open source website that just shows the elevation.

By clicking on “Open Directions in Google Maps,” users will, if on their phone, be able to see the directions they selected inside the Google Maps app and then get turn-by-turn directions along their route (on a computer, a new tab opens with the Google Maps website). Different possible routes can be selected on the right under “Suggested routes.”

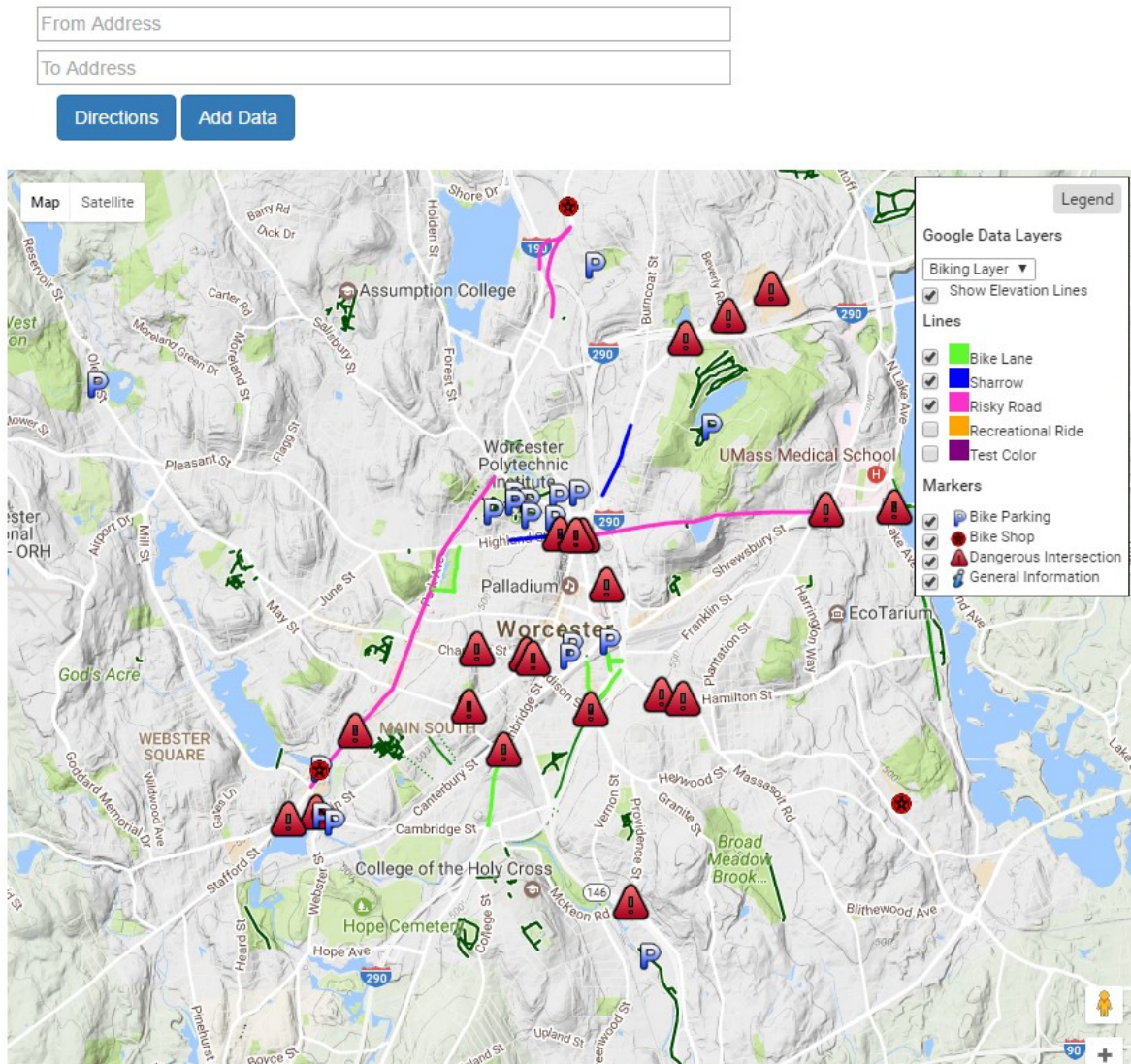


Figure 16: The user's first view of the map upon opening

The map's layout also adjusts on mobile devices to make it easy to use on a phone; the legend can also be hidden to avoid having it take up screen-space on the map.

We also added a simple experimental feature to the map, whereby users could draw lines on the map to indicate where they would like to see bike lanes (using the same line-drawing mechanism as for bike lanes/sharrows/risky roads). Users can then up-vote or down-vote individual lines. The bike lane suggestions were brought up during the feedback interview with CMRPC and the idea of voting up or down on lines/markers of any sort was brought up multiple times by various groups. We are not sure whether or not the bike lane suggesting will become a commonly used feature, but it was simple to add another line type and leave it open to see whether or not it will work out. If this feature works out, it will be extremely valuable to CMRPC in choosing where to put bike lanes; if not, then it will have been a relatively low cost feature to add.

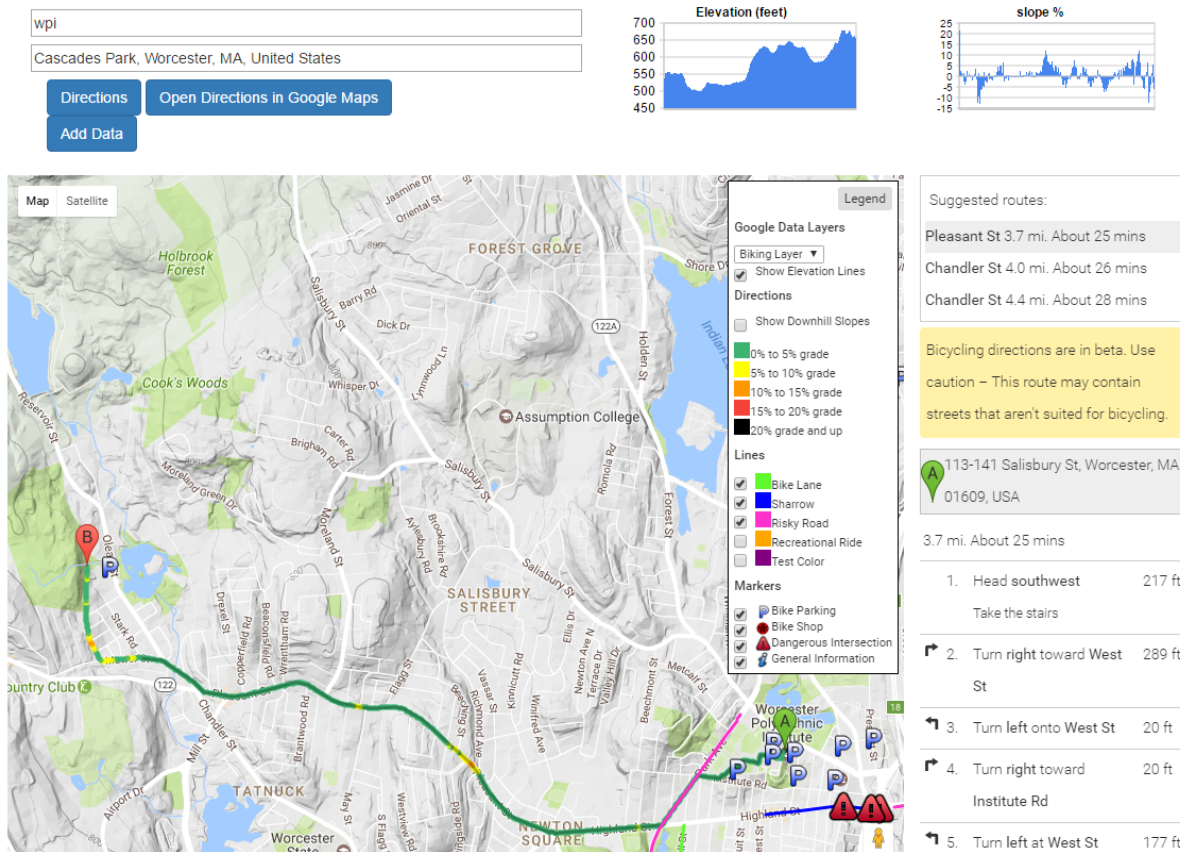


Figure 17: Viewing Directions on the Map

Challenges Encountered

Specific technical issues in the building of the website are documented in the technical documentation. Here, we outline some of the higher level challenges we had in creating the website.

Making the map usable: One of the biggest challenges in creating the map was making all the various features clear to a user who visited the website without reading the user manual. While we made tweaks and improvements based on user feedback (anything from slight changes in wording to adding legend items for grade, among other things), we are not experts in User Interface design and had limited time and resources available.

Getting complete data: Due to a lack of existing data resources, we had to rely on crowd-sourcing for many pieces of data; unfortunately, without a significant user base or an authoritative data source, our data was only partially complete.

Choosing a Routing Algorithm: Although we cover this decision elsewhere, we had to spend time determining whether we should heavily modify existing open source mapping tools or do more minor developments using Google Maps. Due to our lack of familiarity with the options, we ended up spending time investigating the open source modification route and had trouble assessing how much effort it would take relative to using the Google Maps API.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

Summary of Project Deliverables

This resource looks to give bicyclists in the City of Worcester a central resource of information that is relevant to specifically Worcester and cycling in general. The aim of the project was to be able to give bicyclists in the City of Worcester a central hub of information relevant to bicycling.

Ideas from this website were gathered from similar websites that were looking to accomplish a similar task of showing roads and places that are safe for bicyclists. Some features of our map were inspired by the ideas of other websites and maps.

Features of the map include:

- Map of bike lanes, and sharrows
 - May not be fully complete
- Bike parking
 - Includes a description of the type parking which can be helpful for locating a bike rack
- Risky roads: Roads that may be dangerous for bicyclists to ride on
- Dangerous intersections: These are intersections that have high crash statistics and therefore should be avoided if possible.
- Ability for users to add bike lanes/sharrows, risky roads, dangerous intersections, bike parking to the map
- Ability for cyclists from the bicycling community to add roads to the map that are not roads with bike lanes or sharrows, but may be safe alternative for cyclists to ride on
- Feature allowing users to add places where they think that bike lanes should be added

Features on the website include:

- Helpful articles such as:
 - Public Transit
 - Local Bike Shops
 - Group Road Rides in Worcester
 - Massachusetts' Bike Law
 - Recreational routes
- A contact form to make it easy for arbitrary people to get in touch with whomever is maintaining the website

We hope that information contained in the map will be useful to bicyclists who lack knowledge of various aspects of biking in the city. Having a feature that allows users to add places where they think bike lanes should be added was suggested by CMRPC and may be useful to the Planning Departments in the City of Worcester. This feature would give the City an idea of where most people think that bike lanes should be added, so that they can build the most useful bike lanes.

Newer and less experienced cyclists in Worcester are the primary target audience for this website. This includes people who are less familiar with the roads in Worcester and so may not know which are safe and which are not. The main website is also applicable to cyclists everywhere, as information on things such as bike maintenance applies to any location, not just Worcester.

Other people who might use the website are avid bicyclists in Worcester. These are people that have much more knowledge about roads and intersections that are safe and not safe for bicyclists. Ideally, they would find some of the information on the website and map new and useful to them, while contributing their own knowledge to make things better for everyone.

The map is not limited to only the people of Worcester. If there are people in towns around the Worcester area that want to add information to places other than the city proper than they will be able to do so.

Upon Conclusion of the project, The Green Team, which is part of WPI will take control of the website and will provide updates to it regularly.

Recommendations for Future Development of the Digital Resource

Throughout the entirety of the project we gathered data from various sources. In order to improve the resource that we have created, we have specific recommendations for various departments for the City of Worcester, as well as suggestions for anyone that may want to improve the website and map in the future.

The primary focuses for future development are:

- Information on bike lanes in Worcester
- General improvements to the existing map
- Overhauling the map to customize it even more

Information on Bike Lanes in Worcester

These recommendations are towards various departments from the City of Worcester. Recommendations to these various departments in the City of Worcester include conducting more thorough data collection, and finding and retrieving information on bike lanes in Worcester.

Data Collection by Official Agencies

We recommend that official agencies, such as the Department of Public Works, keep track of more data with regards to biking infrastructure. With more specific data and a better knowledge of where bike lanes are located, these agencies will be able to make more informed decisions as to where more biking infrastructure is needed. Furthermore, if the data is published publicly than cyclists will be able to more easily keep track of which roads have provisions for bicycles and which do not, increasing overall safety.

Steve Rolle, in the Planning and Regulatory Department for the City of Worcester, showed us a map of the current bike lanes in Worcester and told us that there were not that many bike lanes in Worcester. Unfortunately, there was no formal documentation to be found regarding the current whereabouts of bike lanes. This brings us to our next recommendation: That of finding and retrieving the information on the current bike lanes in Worcester.

Find and Retrieving Information on Bike Lanes in Worcester

We recommend that the City of Worcester Department of Public Works find and retrieve information on current bike lanes in Worcester. Bike lane information is relevant for the reasons of planning and safety. Finding and retrieving this information is just a step towards the more important goal of dissemination.

Knowing where bike lanes are currently located will give the Department of Planning and Regulatory Services the ability to make more informed decisions as to where biking infrastructure is needed. For example, knowing where all the biking lanes are located will give the Planning Department an idea of where the next most cost-effective bike lanes can be built.

Secondly, as discussed in the Introduction, due to the lack of mapped bike lanes, people don't know where it is safe and not safe to bike. People may be more willing to commute via bicycle if there is more information about where biking is safe. As such, more information on bike lanes should be recorded for the benefit of existing and potential bicycle riders.

Information that should be gathered about each bike lane includes:

- Location/length of the lane
- Width of the lane
- Type of bike lane (Bike lane or sharrow)
- Speed limit of road where bike lane is located
- Whether there is parking along the side of the road where the bike lane is located, and how much space there is between the bike lane and the parking

This information is all relevant because it can provide bicyclists with a better idea of how safe a bike lane will be. For example, some lanes are safer than others. The two major types of lanes are bike lanes and sharrows. Riding on a bike lane is safer than using a lane with sharrows (Alter, 2016). A bike lane gives the bicyclists their own part of the road, while roads with sharrows force bicyclists and cars to share the road. Statistics have shown that there was a correlation between a lower number of bicycle accidents with new bike lanes, compared with adding sharrows had no effect on the number of accidents (Alter, 2016).

There are a lot of factors that affect how safe a bike lane will be. Another example would be two bike lanes, one with cars parking by it and one without. Parking alongside the road puts the cyclists at risk of having a car door opened in front of them or of having a car pull out of a parking space. All these factors help to paint a picture of the safety of the lane. This information will help bicyclists make decisions about what might be the safest road for them to use for their experience. It will provide insight for how comfortable they will feel while riding on that lane.

Future Research and Development

This section explores recommendations for any organization that is interested in the idea of the website and would be looking to improve it.

These recommendations aim to improve the overall functionality of the website and versatility of this digital resource. These include:

- Rewriting the map using an open source alternative
- Fixing outstanding map bugs
- Creating an iPhone/Android compatible app
- Implementing specific suggestions from various groups
- Improving the User Interface

Organizations that this may be of interest to may include:

- Volunteer groups around Worcester (e.g., WalkBike Worcester)

- City Departments
- Student Organizations
- Student Projects

Rewrite Map Using Open Source Alternatives for Greater Customization

We recommend that an organization rewrite the map using open source alternatives as a base platform, instead of using Google Maps as a platform. Using an open source alternative would allow greater customization of mapping features. One of the major benefits of using an open source alternative would have been the customization of the routing algorithm. With Google Maps, there is no way of customizing the routing algorithm. Using an open source alternative would have enabled us to customize the routing algorithm and make routes that could have accounted for variables such as unsafe intersections and risky roads to ride a bicycle on. On the current map, we cannot be sure how much dangerous roads/intersections are accounted for, as Google's algorithm is proprietary. Furthermore, a custom routing algorithm could allow users to customize their preferences (e.g., how much they care about hills), a feature not provided in Google Maps.

One of the main downfalls of using an open source alternative is that it requires more time to develop. Google Maps was the best option for us to use given the time frame, but in the future an open source alternative would ultimately allow for the most customization.

Fix Outstanding Map Bugs

We recommend that an organization fix any outstanding map bugs that may be present in the map. Due to the time constraints given to create the map, we were not able to find and fix all the bugs that may be present. We do not want any bugs that may be present to discourage people from using the map or cause the map to be less effective. A complete list of outstanding bugs and issues may be found in the technical documentation (see Appendix A).

Create an iPhone/Android Compatible App

We recommend creating an application specifically for iPhone and Android operating systems. Creating an iPhone/Android compatible application would ideally give users a smoother experience while using the application on their phone.

The reason a website was chosen was so that it could be more widely accessible. If we created just an iPhone app then this would leave nothing for Android users and vice versa. The decision to create a website was made because we did not have the manpower or time to create an app for both interfaces. With that said, creating an application that is specifically designed for each operating system would allow for more customization and tailoring of the user interface. For instance, an app could be made to run without Internet access, or to directly interface with a phone's camera to allow users to take pictures of bike racks and post them.

Creating an application would provide benefit to ease of user experience, but so long as the website itself is reasonably mobile friendly, it is not absolutely necessary. The website has been used on mobile devices, and the mobile experience is considerably similar to using the map on a computer.

Improving the User Interface

As mentioned earlier, one of the most common issues with the map was people's ability to understand what all the features were and how to use them. While we could make some tweaks, we had neither the time nor the expertise to make a really good and understandable user interface. Future improvements to the map should expect to spend a good amount of time and effort ensuring that the map is usable and understandable to the average user.

Keeping the Website Updated

Anyone who is maintaining the website in the future must continue to actively update content on the website and map. If the content is not periodically updated, then it will over time become less relevant and no longer of much use to potential cyclists. For the map, this will be affected by the presence (or absence) of an active user base—if there are always people actively updating which roads are safe/dangerous, and adding information on the location of new bike lanes and bike racks, then the map will be a valuable resource. If, on the other hand, there is no user base, then the map information will also fall out of date and become useless over time.

Specific Suggestions

These suggestions come from various groups that we were in contact with throughout the time of the project, as well as some suggestions that we have. Some suggestions that we received were bigger tasks that we were not able to implement in the given time-period.

Recommendations include:

- Increase security on the website by moving it over to https (suggested by WPI Green Team)
- Add awareness of the user's current location—for instance, so that they can find the bike rack nearest them (brought up in multiple meetings, including WalkBike Worcester and the WPI Green Team)
- Improve voting system to make it so that individual users can't up/down vote markers and lines more than once
- Spread awareness of the website, such as by regularly attending community biking events or by regularly sending out emails to new users of the WPI bike share. If Worcester ever creates a bike share, then perhaps new bike share users could be given a link to the website
- Add automated information about every individual road, such as speed limits, shoulder width, number of lanes, etc. Some of this information can be found via official sources in the MassGIS and MassDOT GIS systems, and we simply didn't have the opportunity or ability to include in our map, but some of it may be harder to find
- Ensure that the website is continually updated with new information. If the information on the website becomes out of date, then it will become ever more useless over time
- See the Technical Documentation in Appendix A for some more suggestions

APPENDIX A: DOCUMENTATION

See this Google Doc for detailed technical documentation of the implementation of the website. This is directed at the people who might be programming the map or website themselves:

<https://docs.google.com/document/d/1RnK6cNr9uUIWaiiOslDzKCjXmKY834luh3LB9z2GOs/edit#heading=h.9e04nr27ld51>

And see this Google Doc for a user manual directed at those who might have accounts on the website and would be using the website themselves; you should not need any particular technical expertise to be able to understand everything in the user manual:

<https://docs.google.com/document/d/1KfG-3zKTlq3rmvSNuxkPZQ3wR86Arn6HSODLmGciY7g/edit>

APPENDIX B: INTERVIEWS

Interview with Central Massachusetts Regional Planning Commission (CMRPC)

10/26/2016 – Dan Daniska and Melissa Santley

- **How would you describe what CMRPC does?**
 - Promote alternate forms of transportation in Worcester. Along with bicycling and pedestrian planning. Big current project is creating more biking areas throughout the city.
- **What are the CMRPC's plans/priorities for the future, with regards to bikes?**
 - Biking is a very high priority for CMRPC; most of work load. Worcester is difficult for biking infrastructure because of its size and complex roadways. Working on having more bike lane painted on streets, but there are no specific plans for this to be done yet. Bike parking is a major priority for future. Providing them a list of areas for effective bike parking would be good also adding bike parking locations in the digital resource. The Worcester Regional Chamber of Commerce is currently working on a city-wide bike share program, but it is in the very beginning stages. Other future plans are an extension onto the Blackstone Valley Bike trail, Park St/Chandler St bike lanes, connecting the cities colleges with bike lanes, upcoming Main St repave which will have new bike lines, extended bike lane by Clark University to Union Station and Webster Center.
- **Does CMRPC have any plans to make any resources available digitally? Do you know anything about how other cities might have dealt with this?**
 - Did not ask
- **Are there any other organizations we should get into contact with?**
 - Talking to WalkBikeWorcester is a great place to start, Dan Daniska can provide an email introduction when ready. WalkBikeWorcester meets once a month, meeting with the cochairman would be a great start. Next meeting is October 6th. Also, contacting MassRides (Taylor, which we have already been email introduced too) and Landry's Bike shop, Landry's is very involved in the community, located on

Grafton St. Also, a group called Action Worcester, founder is from WPI, located on Franklin St. They work with young people to find a way to make the city a better place. They have their “idea lab” on Wednesdays great to attend to gain connections. Jacqueline Ewuoso from The Worcester Division of Public Health could be a great contact.

- **What would you like to see in something like this?**
 - Something that provides the fastest and safest way to get from point A to point B depending on time of day. Something that also lists places of interest throughout Worcester that people could bike to; scenic routes.
- **What have planning commissions done?**
 - Planning commission have pushed the idea of adding bike lanes when roads are being repaved or lines repainted. No separate construction plans to go out and widen roads for bike lanes currently. Talk about adding biking parking at public library, public schools, and at town hall.
- **What colleges or parts of the city are most advanced in bikeability?**
 - Did not ask
- **Where can we find information detailing road conditions? Bike lanes, speed limit, number of lanes, etc.**
 - Some of the information above can be found on CMRPCs website, but will all be 2-3 years old. Traffic statistics and number of accidents would be information found on the Worcester Police Departments website.
- **When you talk to cyclists/stakeholders, what do they complain about? is there any data on the cycling community in Worcester? How far people are biking, how many are commuting vs. recreation vs. using it to get around town, where people are biking from/to etc.**
 - Stakeholders complain about lack of bike parking areas and biking lanes throughout the city. Many complaints about how poorly signed/lined current bike lanes are. As far as data for cycling in the community, Landry’s bike shop would be a great place so ask about that since they are heavily involved with biking in the community. Most riders seem to be biking from the outer edge of Worcester into the city and from the train station to their work.
- **Bike lockers at Union Station?**
 - Bike lockers at Union Station are free for the first year, and 100 dollars a year after that compared to the roughly 150 to park your car every month in a garage. The lockers are located upstairs on the side where the train tracks face the city. Jon Odell oversees the bike locker contracts.
- **MBTA Commuter Rail bikes during peak hours?**
 - During peak hours, the commuter rail is very busy making it hard to get a bike on. Newer carts that travel to Manhattan have bike racks on them.
- **Anything exciting happening with the new bike parking project in Worcester?**
 - Currently considering the best locations that would be the most feasible. Feedback on where they should be located will help move their project forward. Locations must be public areas such as public schools, libraries, etc.

Interview with WalkBikeWorcester,

11/3/2016—The format of this was such that we had two of us each talking about things with a group of 4-5 people.

The following were mentioned:

- The following might want to be considered for showing on the map/including in a routing algorithm:
 - Road conditions
 - Shoulder Sizes
 - Terrain
 - Traffic conditions (particularly the average speed of cars on various roads)
 - “Low-stress” routes (perhaps slower, fewer stop lights)
 - Avoid stop signs
 - Avoid bus routes, due to buses pulling over a lot
 - Places with lots of driveways where cars may be pulling in/out
 - Roads with parking on the side of the road,
 - Good recreational routes
 - Good locations (bike friendly businesses, touristy locations)
 - Brought up 3cross brewery as example of bike-friendly business
 - How well marked roads are (on roads with faded markings, apparently cars tend to “wander” side-to-side, reducing space available for cyclists)
 - Good routes for going between colleges (also brought up by Bike shops)
- When asked about an app vs. website, some people preferred an app for its offline convenience; however, when some of the tradeoffs were brought up (namely, that we would probably only be able to do one of iPhone/Android, and it would be inaccessible on a computer), more people preferred a website
- On website, include information on:
 - Bike groups/cycling clubs
 - Rules of the road
 - Specifically noted seeing WPI students with bike-share bikes on sidewalks
 - Perhaps some static maps of common/useful routes
 - Safety and maintenance tips
- No one was quite sure who would be good to have maintain the app/website

Interview with Fritz’s Bicycle Shop,

11/16/2016 – Aaron Prince

- Mentioned problematic intersections
 -
- Also, suggested riding bikes on sidewalks when needed too
- Mentioned some routes that they use to circumvent the roads near them, which involve carrying the bike down a staircase.
- We could include a section that advertises for people looking to buy a bike could get a used bike that would be cheaper. Many people may not be aware of this as a resource and so may be less likely to even consider buying a bike if they think that they must pay a lot for a new bike.

- Mentioned Dan Rees of WalkBike Worcester as being someone who may be useful to talk to.
 - Apparently, he wrote some article about riding in Worcester:
<http://www.telegram.com/article/20150919/NEWS/150919082>

Interview with Barney's Bicycle,

11/16/2016 – Peter Howard

- Suggested emphasizing some predefined, good routes between the various colleges
- The most efficient bike lines for Worcester would be on Park Ave, Chandler St, or Pleasant St, because they are necessary for getting through the city.
- Mentioned Holden Reservoir for recreational riding in the area.
- Suggests that some cyclists ride on the sidewalks if they are going slowly and can't contend with traffic.
- Mentioned that we might simply suggest walking the bike in some intersections which are otherwise unnavigable.
- Mentioned Shrewsbury, Mill, and June streets as useful for getting around some of the inconvenient biking areas in Worcester.

Interview with Bikes and Life,

11/16/2016 – Neil Medin

- Person originally contacted through email was not available
 - Spoke with Neil Medin for short time
- Mentioned wanting data about traffic flow, shoulder width, parking on side of road, emphasizing safety lights
- Mentioned that Bike and Life does group rides and runs various clinics in the Worcester area

APPENDIX C: Website Feedback

Below are various suggestions from people after visiting our website.

Amy West, Sent feedback via email (2/5/17)

- Add an article about “What to do if your bike is stolen?”
- Add an article about “What to do if there’s no bike rack”
- Add links to info about bike paths in/near Worcester
- Would be a nice feature to have the map locate the nearest bike map

David Dayan, Sent feedback via email (2/7/17)

- Keep the website updated and make it visible
- Either having a dedicated webmaster with a long term commitment for upkeep or including some tool to allow users to update the site would be key in making sure this website has a positive, sustained impact on Worcester
- Outreach, promotion and visibility are probably the most important factors determining the impact of any web-based resource
- With regards on how to improve the article on Safety tips: a handful of additional data-based, user oriented resources would improve this section
- Include links of the short series of videos produced by University of Miami’s BikeSafe program
- With regards on how to improve the map:
 - Include a description of what’s going on with the map may encourage people to use this map as opposed to Google maps
 - Allow users to enter road ratings
 - Allow users to mark what routes they frequently use and which routes could be improved

Carlos Barcelos, WPI Green Team Vice President (1/25/17)

After meeting with Carlos Barcoles, he offered the following feedback(which he wrote himself):

- Security
 - This website is NOT secure! What is the password being saved as? Plain text? Highly insecure. The first thing you need to do is obtain a SSL certificate for this domain name and apply it so that user’s passwords do not get intercepted.
- Website
 - Preamble – I love the website and think it is a great idea! But I need to ask to see your motivation: Why should I use this site instead of Google Maps and checking bike routes? What makes this website better?
- General
 - Your website is very friendly from a technological standpoint. You can get an accessibility report from <https://testmysite.thinkwithgoogle.com/>. I did a quick test and you got good/fair ratings for desk
- About Page

- Why not add a link to your IQP report?
- Tips and Resources
 - Consider adding folders for these articles. Tips and Resources are already two sub-topics. The top layer page should be called resources with such sub-categories as “Tips”, “Maintenance”, “Leisure”, “Safety”, etc.
 - Consider a better formatting. Right now it is difficult to differentiate one article from another due to the font color and the large percentage of the block that is dedicated to the “Read more/login/register” portion. Adding a different background or more defined border to each article post would make it easier to navigate.
 - In general, try to use more images, unique fonts/colors/bolding and other things to make the articles more engaging. Also, not sure what the CMS looks like but the margins on the article are tight. And the way they are contained in the <p> doesn’t seem optimal; you don’t necessarily need the
 in there because the text already wraps when the screen gets smaller.
- Specific Articles
 - Mass. Bike Laws
 - Give more information on this page itself. I can go to the massbike site but if I wanted to do that I would have gone there instead. [Also, the link you have there is out of date.]
 - Bike Safety
 - Same as above
- Map
 - The sizing on the map doesn’t allow you to look at all of the information at one time. That is an important note especially on mobile. One tip I can give is to reduce the disclaimer at the bottom of the screen to a pop-out box. Create a button called “Usage” and make that information pop-out on click. Otherwise, certain sizing options could make this fit better on one screen of a webpage.
 - It would also be a useful feature to remove the custom route points that are added to the map.
 - When scrolling over the Elevation and Slope charts, it only tracks on the map when you move the cursor into the blue range. However, this become difficult when the slope is all over the place and it goes from blue positive to blue negative quickly. Instead, it would be move useful for the chart to track the mouse and display on the map simply depending on the x-axis and not the data.
 - Finally, from your maps page there is no way to get back to the main website. Add a home button for ease.
- Lines
 - How are these lines defined?
 - Most of the lines are labeled “Bike Lane” but not all of those roads have bike lanes on them.
 - What is “Sharrow”? For the common user it would be beneficial to rename this to “Shared Lane”
 - On a route that takes Park St., it was not labeled as a risky road when in fact it is as pretty risky road. This goes back into the question of ‘how are these lines defined?’

- Markers
 - Where are you getting data for all of these markers? It might be useful to crowdsource this effort. For example, if I encounter a new bike rack on campus I could submit a marker on the app. You could either approve it as an administrator or allow other users to vote up that marker to confirm that there is something there.
- Routes
 - How are routes calculated. It is certainly not shortest distance:
 - From what it looks like, it is “safest route” which is great! However it would be nice to have an option to sort between “bike safe” and “fastest” routes.
- Performance
 - The map works pretty well for the Map view but not very well during Satellite view. It takes a while to update and has to update more frequently than I was will to wait. Are there any performance upgrades that you came across during your research that you could implement?
- Contact
 - Nice job catching bad email addresses. What email address do those emails go to? Is there a bikemap@wpi.edu admin account that is also the same place as the new user registration goes? This would be easier to pass around than having

Meeting with Dan Daniska and Melissa Santley from CMRPC (1/30/17)

After Meeting with Dan Daniska and Meliss Santley from CMRPC they offered the following feedback for the website and the map:

- Website Feedback
 - Promote the Website on WPI’s Facebook page, or the Green Team’s Facebook page
 - Organize the Tips and Resources into different subsections
 - Bike Safety
 - Urban Cycling Safety Tips
 - Add MA Bike Laws to a bulleted list
 - Crash tips for what to do if you are in a bike accident
 - ABC Bike Check
 - Public Transit and Bike Section
 - Local and State Organizations
 - Walk Bike Worcester
 - Seven Hills Wheelmen
 - Bike Shops
 - Benefits of Cycling
 - Didn’t think that many people would be interested in that article
 - Shorten it and just add a couple quotes from other websites
 - Possible Options for the home page
 - Add Pictures to the home page
 - Move Map onto the home page
 - Update the home page to describe what it is about
- Map Feedback

- Announce the Map as a collaborative effort in order to make sure that people know that they can add data to the map.
- Send out the map to WPI students to see what information they can add to the map.
- Add Descriptions to the lines
- Add Lines on the map for suggested
 - roads to ride on
 - where bike lanes should be added
 - See how many people suggest a certain road have a bike lane and that could be used for some sort of city planning.
- Add descriptions to the lines
- In regards to the bike parking
 - Add pictures of the bike parking
 - Give the capacity of the bike rack
- Mark the dark green lines as Google's walking and biking lines
- Listed some bike lanes that were not found on the map
 - Hamilton Street
 - Southbridge Street from Cambridge Street to Hammond Street
 - Sharrows on Russel Street

Barney's Bicycle Shop(2/14/17)

- First impressions of map
 - Lots of warning signs
 - Some colors of lines/markers on the map did not stick out, specifically the green and orange
 - Did not believe that an option to filter lines/markers was necessary
 - Did not know what sharrows were
 - Did not know how to add data until instructed on how to do so
 - Suggested more user friendly instructions
 - Thought elevation markings along routes was neat

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